The Dock and Harbour Authority

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Editorial Comments

The Thames and the Port of London.

Although by no means the longest, or the largest river, in the British Isles, the Thames enjoys a notable prestige not only in Great Britain, but even among the great rivers of the world by reason of the enormous volume of commerce which is annually transported to and from its banks. Apart from its shipping and commercial importance, however, it possesses a number of features which are of great technical interest to the hydrographer, the maritime engineer and the navigator. Our readers will welcome, then, the opportunity of reading a comprehensive and detailed Paper on the Yantlet Dredged Channel in the Thames Estuary by Commander Shankland, the River Superintendent and Chief Harbour Master of the Port of London Authority, which was prepared for and arranged to be read at the XVIIth Congress of the International Association of Navigation Congresses at Berlin during the summer of 1940. Unfortunately, the war intervened, and the address could not be delivered. Commander Shankland has been good enough to place it at the disposal of this Journal.

The Thames rises in the Cotswolds and in its course to the sea has a length of 210 miles (10 miles less than the Severn) through the County of Middlesex and along the boundary lines of Gloucestershire, Wiltshire, Berkshire, Oxfordshire, Buckinghamshire, Essex and Kent, the last two counties being more widely separated than the others. It is in these lower reaches that the river attains its greatest importance, and its close association with the capital and metropolis of England has led to the title of "London River" being given to the estuary from London Bridge to the sea. In fact, the estuary is essentially bound up with the Port of London, and the two can hardly be considered apart.

"To what causes is the progress of London as a port due?" asks Sir Joseph Broodbank in his classical History of the Port of London. Answering his own question, he says: "Many circumstances have been at work, but the chief is the geographical and physical advantages which it enjoys. The geographical advantages apply to the question of the distribution of goods—a primary function of a port. It may be pointed out that the situation of London is about sixty miles from the sea, i.e., about the distance which an ordinary steamer can cover while the incoming or outgoing tide flows. This situation enables goods to be brought into a district where the radius of distribution by land is very extensive, and yet it is not too far inland to interfere with distribution by sea if it is desired" (p. 4).

Thus it can be seen that the Thames Estuary fulfils a strikingly essential rôle in promoting the interests and welfare of the greatest port in the British Empire and justifies the verdict pronounced in the Royal Commission Report of 16th June, 1902, after a prolonged and searching enquiry into the administration and operation of the port prior to its establishment under its present statutory authority:—

"In conclusion, we desire to state that our enquiry into the conditions of the Port of London has convinced us of its splendid natural advantages. Among these are the geographical position of the port; the magnitude, wealth and energy of the population behind it; the fine approach from the sea, the river tides, strong enough to transport traffic easily to all parts, yet not so violent as to make navigation difficult; land along the shores of a character suitable for dock construction and all commercial purposes."

Other ports are situated on notable and commodious rivers, but for various reasons they have failed to gain the prominence of London. And for such time as "Old Father Thames goes rolling along" to the sea, so long will the Port of London maintain its supremacy in maritime affairs, since, as will be seen in Commander Shankland's Paper, the care and improvement of the navigable channel has been and continues to be one of the chief concerns of the Port of London Authority.

The Dock and Harbour Authorities' Association.

For the first time in its existence of 21 years, the annual meeting of the Dock and Harbour Authorities' Association has been held this year out of London. The lateness of the date (26th February) at a time when the March issue of this Journal was already at press, precluded any account being given in that issue of the proceedings. A report will be found in another column of the present issue.

The meeting was also noteworthy by reason of the resignation of the Presidency by Lord Ritchie, Chairman of the Port of London Authority and the appointment of his successor, Sir John Irvin, Chairman of the Aberdeen Harbour Commissioners. Lord Ritchie vacated his office, the duties of which he has discharged with conspicuous distinction and energy, amid a chorus of praise from all the representatives of the constituent bodies who passed unanimously a resolution expressing their grateful appreciation of his services.

Sir John Irvin meets with the warm support of his colleagues in taking up the responsible task of guiding the destinies of the Association. From his long association with the Port of Aberdeen and by reason of his official connection with the Board of Harbour Commissioners for nearly 40 years, he is admirably qualified for this duty.

Transit Sheds and Port Congestion.

During the past month or two, port congestion troubles have not only been keenly discussed in port circles, but they have also been the subject of comment in the public press, accompanied sometimes by well-informed expressions of opinion. A London evening journal recently quoted the views of a stevedore "with unique experience in discharging ships in the last war." He pointed out what, of course, every dock traffic manager or superintendent fully realises, viz., that the convoy system results in the arrival of ships in port in such numbers that the quayside shed accommodation is frequently over-taxed and the available floor area so crowded with goods that the process of sorting to marks cannot be carried on with sufficient celerity to clear the berths in time for the queues of vessels awaiting their turn.

The expert propounded his "simple remedy" as follows: "To build transit sheds far away in the country, where there is room for many more of them than could be accommodated in the port itself. Roads leading to them should run out straight for fast traffic, like spokes of a giant wheel, its hub being the port." The plan, he added, is not new, having worked well in France in 1917.

Undoubtedly, the proposal has its merits, especially when a clear field exists for its application, but it may not be so easy of adoption in ports located (as many are) amid the crowded purlieus of a thickly populated district, where "straight lines for fast traffic" would scarcely be practicable. It would unquestionably be an advantage to get the heterogeneous mass of goods from an incoming vessel transported away from the quay front to a site where sorting and classification could proceed in comparative leisure. With marks running to several hundreds per ship in peace time, the normal allowance of 48 to 72 hours for the removal of their goods by the consignees can ill be spared under convoy conditions. In the case of double and treble-storey sheds, the

Editorial Comments – continued

trouble would not be so acute as with single-storey sheds, but it has to be borne in mind that multi-storeyed sheds tend to monopolise the road and rail approaches to the sheds to an inconvenient degree.

Apart from the need for rapid transport, the plan would necessitate the construction at suitable sites of a number of sheds to receive the goods, but this, perhaps, would not involve much difficulty, since light, single-storey structures would suffice to provide temporary storage of short duration for goods *en route* to warehouse or consumer.

At any rate, the matter is worthy of consideration, especially as it is claimed that the system worked satisfactorily during the last war.

The Mersey Goods Permit.

The Mersey Goods Shipment Permit, the text of which was published in our last issue and which came into force on March 12th, has not escaped a certain amount of criticism. It was attacked particularly at a recent meeting of the Council of the Liverpool Chamber of Commerce, which had previously taken an active part in calling attention to the unsatisfactory arrangements at the Port of Liverpool. There have also been adverse comments from other quarters.

Objections which have been raised are principally that "it will not work in the coasting trade"; that it means a great deal more trouble for the staffs of forwarding and shipping agents; that it will not benefit cases where there is little or no liability to congestion; that unless permits accompany goods on rail, as well as by road, the former may not be accepted at the docks; and that there is no assurance under present conditions that goods will arrive on the date stated on the Permit.

On the other hand, it can be claimed that in place of existing uncertainties, shipping agents will know exactly what they have to deal with on particular dates; they will know precisely to whom to turn in case of default or complaint; outward-bound consignments will be maintained in better order; shipments will be regularised and goods will be kept clear of the quays until near the time for loading.

There is a well-known proverb, current in Lancashire, which says that "the proof of the pudding lies in the eating." It would be well to suspend judgment until a fair trial of the system has been made.

The Port Labour Question.

The problem of Port Labour is perennial. Despite the numerous attempts which have been made to deal with it by port authorities and government commissions, it cannot be said that any pronounced success has been achieved. Possibly, under the stress and urgency of present war-time conditions, the problem may finally be solved, for the Ministry of Labour and the Ministry of Transport have now taken the matter seriously in hand. Orders have been issued and a detailed scheme promulgated, applicable at the moment, it is true, only to ports at Merseyside and vicinity, but capable of wider application, if it proves to be efficacious in that locality.

The fundamental difficulty has always been the deeply-rooted objection of the dock labourers to anything in the form of steady and continuous employment. Recruited in bye-gone years very largely, and indeed mainly, from the ranks of the "down and out," the hopeless and the otherwise unemployable, dockers, as a class, have regrettably acquired the characteristics of casualness and "happy-go-luckiness," careless of all thought for the morrow. If they chanced to get a day or two's work to carry them over a spell of unemployment, some, impelled by hunger, accepted it eagerly, others nonchalantly, and with indifference. They acquired the habit of working a few days per week as jobs offered, and idling the rest of the time. Their attitude and the resultant situation was only too accurately summed up in the Shaw Report of 1919.

"Casualization," it stated, "and that upon a large scale, seems to have become part and parcel of the dock industry, and has been accentuated since the outbreak of war. It was, and it remains one of the most appalling problems which confront all those engaged in social amelioration or philanthropic effort. Since the war, it has reached the dimensions of a serious social disease. The spectacle of men, who, after all, have the obligations of citizenship resting upon them, being assembled at the dock gates, uncertain whether they are to enter the ranks of labour for even half-a-day, or to be left a prey to those temptations which spring from idleness, poverty and a sense of neglect, is not one which can be treated by an independent and humane mind with equanimity."

The reference in the foregoing extract is, of course, to the previous Great War of 1914-18, since which epoch various creditable attempts have been made, with greater or less success, by the leading port authorities to regularise their labour supply by means of registration and classification in order of priority of calling on, but the underlying objection of the docker to continuous and systematic employment has been fostered and encouraged by the irregularities of shipping movements and the vicissitudes in the local demand for quayside labour.

This uncertainty of opportunity for employment is really the crux of the matter. Dependent on the actual arrivals of ships in port, sometimes there is a glut of labour available; at other times, less frequently perhaps, a scarcity. This has been accentuated by the convoy system and the diversion of vessels to other than their normal home ports. In October, 1938, an attempt was made to deal with these uncertain factors by the formation of a Corps of Mobile Port Labour. The Ministry of Labour, with the co-operation of the National Council of Port Labour Employers and the Transport and General Workers' Union, instituted a scheme under which men could register themselves as willing to be transferred temporarily from their home ports to wherever their services might be required, the Government undertaking to pay travelling expenses and to guarantee a minimum wage until the men had completed their job and were sent home.

The terms of the present scheme, which follow somewhat on the same lines, but with the local limitation specified above, will be found elsewhere in this issue. Two points are of outstanding importance: the arrangement is entirely voluntary on the part of the men, and it is a war-time emergency measure to be discontinued at the conclusion of hostilities.

On both these points we feel there is ground for disappointment. The national emergency is so great and the defects in port working have been lately so notorious, that the same element of compulsory service as obtains in the Army should, in our view, have been incorporated in the dock labour scheme. Moreover, as the scheme is merely temporary for the duration of the war, it does nothing to ensure a permanent remedy for what is described in the Shaw Report as "a serious social disease." It will require a more determined and resolute effort on the part of the Government to do away with the evil of casualization in port labour, which has so largely eluded the statesmanship and capacity of port authorities in the management of their affairs.

The obstinacy with which dock labour defends its preference for casual employment is manifest from reports which reach us, at the time of writing, of the reception of somewhat similar proposals at the Port of Glasgow. These proposals are likewise set out in a later page of this issue. It has been officially announced by the secretary of the Scottish Transport and General Workers' Union that the men are opposed to them "on the ground of impracticability." Subsequently, Mr. Letch, the Regional Port Director, has stated that this decision will not affect the Government's intentions to proceed with the matter, and negotiations are in hand with a view to reaching an amicable settlement.

We should not omit a reference to the Order for the Provision of Dock Canteens, which accompanies the memorandum on the Organisation of Port Labour. This is a very sensible step and it will do much to raise the standard of comfort and cleanliness among the men employed. It should, therefore, act as an inducement to them to consider the advantages of regular and settled employment.

The Ports of Italian Somaliland.

The transfer of the main theatre of war in Northern Africa from Libya to the extreme North-eastern sector of the Continent has directed attention to the port of Italian Somaliland, which, it has to be admitted, are as few in number as they are deficient in good harbourage. Practically, there are only two of any note: Mogadishu, or Mogadiscio, the capital, and Kismayu, at the mouth of the Juba River. Other towns on the coast are Brava, Marka and Warsheik—they are all included in the generic term, El Benadir (the ports) which is the name applied to the coast generally

The coast-line, indeed, is largely rock-bound, with few indentations. The only passable natural harbour is Kismayu. The Juba River, at the mouth of which it stands, enters the sea across a rather dangerous bar, which has only a single fathom depth of water even at high tide. The river itself is navigable by shallow-draught steamers; in fact, just above the mouth, it is rather a fine stream, 250 yards in width with a current of $2\frac{1}{4}$ knots. The course of the river exceeds a thousand miles to the sea from the highlands in the South-eastern border of Abyssinia. On its banks at a distance of rather less than 400 miles from the mouth is the important town of Bardera.

At one time, the river Juba formed the boundary between Italian Somaliland and the British colony of Kenya, but in 1925, the greater part of the province of Jubaland, some 36,000 sq. miles in area, including the Port of Kismayu was detached from Kenya and transferred to Italy. The region is fertile and the Italians have cultivated cotton, sugar cane, rice, bananas and maize. The indigenous trade is chiefly in dressed skins, cattle, frankincense, myrrh and gum arabic.

There is little information available about the berthage accommodation at the Somaliland ports. Just before the entry of Italy into the war, it had been decided to undertake improvement works at Mogadishu, Marka and Kismayu. A new basin was proposed at Mogadishu and equipment for handling bananas was to be provided at Marka. At Kismayu, the works contemplated included new moles or breakwaters, aggregating 7,700 metres in length and a quay, 450 metres long with a depth alongside of 5 to 12 metres.

Yantlet Dredged Channel in the Thames Estuary

A Contribution on Hydrographic Research and Development

By Commander E. C. SHANKLAND, R.N.R., F.R.S.E., F.R.Met.S.
River Superintendent, Port of London.

Characteristics of the Port Estuarial Approaches

WHEN the autonomous Port of London was formed in 1909, a statutory duty was laid upon the new authority to improve the channels of the tidal Thames and in particular to develop an approach channel between the seaward limit of the Port and Gravesend—a distance of 24 miles (English statute). The requirement for this channel was a dimension of 30-ft. deep and 1,000-ft. wide at Low Water Ordinary Spring Tides.

Concurrently it was decided by the enterprise of the Authority to improve the dock facilities near London and the large King George V Dock was designed. It therefore became necessary to expedite the channel improvements at the mouth of the Port and 40 miles from the King George V Dock in Galleons Reach.

To navigate vessels of considerable draft and tonnage limits the speed on passage to about 8 knots (37-ft. draft has occurred and the new "Mauretania" has a tonnage of 35,000 gross). During the passage through a waterway which varies from 1,400-ft. to 2,000-ft. in width, the vessel must ease speed at Gravesend for Customs, Pratique and change of Pilots—and in consequence it is desirable that large vessels should arrive at Gravesend 1 hour before high water at that place, leaving 2 hours for comfortable passage of the remaining 16 miles and for docking operations at London. The time lag of the progressive high waters enables shipping to precede the tidal crest at the speed indicated above.

The tidal Thames has an accurately balanced semi-diurnal tide of exceptional regularity with a period of rise 5.8 hours and a period of fall of 6.5 hours in Galleons Reach where the principal dock entrance is situated. High water occurs in Galleons Reach one hour later than at Southend-on-Sea under normal conditions.

The duration of rise and fall varies as the river is ascended or descended, as also does the range of tide, King George V Dock being situated in the tidal compartment where the range of tide is greatest.

When the Thames is in flood there is a predominating down stream irrespective of rise and fall for one-third of its tidal course (24 miles).

At Southend—the mouth of the Port—the duration of the tides is as follows—from automatic tide gauge records:—

Duration of rise	Spring Tides	5 hrs. 57 mins.	Mean difference 17½ minutes rise and fall
	Neap Tides	6 hrs. 17 mins.	
Duration of fall	Spring Tides	6 hrs. 19 mins.	
	Neap Tides	6 hrs. 2 mins.	

	H. M.		H. M.	TOTAL TIDE CURVE
Spring rise	5.57	+ Spring fall	6.19	= 12 hrs. 16 mins.
Neap rise	6.17	+ Neap fall	6. 2	= 12 hrs. 19 mins.

On Spring tides the lateral drainage stream runs out about 30 minutes longer in the central channel than the actual fall of tide level indicates by the curves at Southend-on-Sea. This longer duration of the Spring tide on the outgoing stream is an important factor in the regime of the Thames Estuary.

The purpose of this Paper is to describe the hydrography tidal and dredging research covering the more difficult operations in channel improvements mainly between 1922 and 1938 in the Yantlet Channel area, at the seaward limit of the Port. The major dredging difficulties were surmounted between 1922 and 1925, but until 1938 trimming to adjust curvature and small corrections to depth has taken place.

The general plan for the authority's new channels to King George V Dock was as follows: passing through Sea Reach, Lower Hope Reach, Gravesend Reach, Northfleet Hope, St. Clement's Reach, Long Reach, Erith Sands, Erith Reach, Halfway Reach, Barking Reach and Galleons Reach.

(1) Nore Lightship (Entrance) to Erith Reach 34 miles, width 1,000-ft., depth 30-ft. at L.W.O.S.T.
(2) Erith Reach to King George V Dock 6 miles, width 600-ft., depth 27-ft. at L.W.O.S.T.

} 40 Statute miles.

This general plan has been completed and its extension to London Bridge is in course of completion.

*A Paper approved by the Ministry of Transport for presentation at the proposed XVIIth International Association of Navigation Congresses Meeting in 1940.

The Thames Estuary which influences the tidal supply of the inner waterway covers approximately 250 square miles of natural deep water channels lying N.E./S.W. passing between sand banks which dry at low tide and stretch seawards into the North Sea to the east of the longitude of North Foreland, 35 miles from the dredged channel at the Nore.

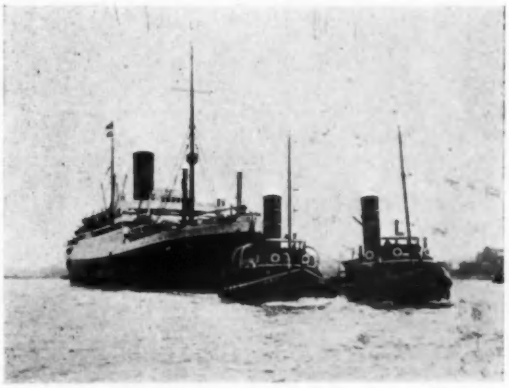
These sand banks lie upon a chalk base at great depths proved by borings taken under the direction of the General Lighthouse Authority for the purpose of considering the erection of lighthouses on the sand banks in recent years.

The sea-bed material consists mainly of littoral drift in the form of fine sand and shell. Alluvium and detritus has combined to consolidate the banks although some retain a quicksand or shivering character. The detritus comes from the following rivers which drain into the estuary:—

Thames	Crouch
Medway	Blackwater
	Colne

with a catchment area of about 6,000 square miles.

In the outer estuary the banks and cross channels continue to change their situation and character. These changes may be of a gradual or long term type, while others are of short periodical type, but none is of an acute or of violent activity.



A Liner in Tow in the Estuary.

The main channels of fixed character are the West Swin, Barrow Deep, and Black Deep—the tidal Thames receives its main supply of sea water from the West Swin and Barrow Deep, because in the matter of tidal phenomena the tidal wave which passes southward through the North Sea and retreats north again, accounts for our semi-diurnal high waters and low waters in the Port of London.

The main tide enters the North Sea between Scotland and Norway, the Channel tide via Dover Straits having little, if any, effect. In the Flemish bight the progress is rotary in character and an amphidromic point, where the lunar semi-diurnal constituent has zero range, occurs in the centre. The range of the semi-diurnal tide increases in all directions from an amphidromic point so that in the Thames Estuary it may reach 18-ft.

The tidal wave which arrives in the Estuary via Straits of Dover is therefore a small contribution to the whole estuarial capacity and as it arrives later it joins for a short period the retreating or north-going stream and thus creates the cross-cut channels and swatchways which in some places divide the long sand banks.

Through these approach channels the greatest port tonnage in the World passes.

It was at the border line of the littoral drift and river silt deposits that dredging problems gave most concern, because of the exposure to weather while dredging and the uncertain history of this area from previous hydrographic surveys.

It is to this embouchure area—8 miles in length with a mean width of 3.4 miles—that the following details are directed.

For several generations proved by the geological formations to extend to 3,000 to 4,000 B.C. the Thames has been laying down its silt and spreading it over a wide area in the estuary which is of the typical bellmouth formation.

The natural corollary to such a bellmouth is the dissipation of tidal energy in this region for the discharge, and affecting the tidal stream in the course of 8 miles we had brought under study for development for a deep water channel.

Yantlet Dredged Channel in the Thames Estuary—continued

It should be kept in mind that only a small fraction of the water passing out of the Thames on discharge is fresh water. As a matter of fact the figures are as follows:—

Measured through a cross section at Gravesend	Salt Water—Spring Tide discharge 65,556,000,000 galls. per 12 hours.
	Fresh Water—Standard discharge 1,357 galls. per 24 hours.

When a chart of Sea Reach was made in 1894 it showed that the region referred to was encumbered with sands having no defined deep water channel and that the river and sea currents spread over it irregularly with depths for navigation which varied near the centre from 18 to 24-ft. at Low Water Ordinary Spring Tides.

The situation was complicated also by the mouth of the River Medway which discharged at a central point in the Estuary. This point was also a focus for shipping entering the Port of London, a natural area for manœuvre and close to the position at which our new dredged channel now has its entrance.

This close proximity has not been found in any respect detrimental to maintenance of depth, because the two outlets have found a common point of convergence suitable to their to their hydraulic needs.

The material deposited in the estuary by these rivers is of very fine grain and measures—

	Parts per 100,000.		Grains per gall.
At Barking	11.52	=	8.06
At Southend Pier ...	1.40	=	0.98

The determination of the weight of dried sediment per unit of volume of wet silt is as follows:—

(1) 1,500 ft. N.W. of Nore Lightship	1,087	Ounces (Avoirdupois) of dry material per cubic foot of wet silt.
(2) 5,200 ft. E. of No. 1 Buoy	1,090	
(3) 5,000 ft. E. of No. 2 Buoy	970	
(4) 5,000 ft. E. of No. 3 Buoy	1,180	

Nos. 1, 2 and 4 are all fine silt; but No. 3 contains a slight percentage of coarse particles.

The Thames flows through chalk and the London clay. The amount in suspension is normally 8.06 grains to the gallon in the middle reaches of the River as compared with .42 grains to the gallon in the Black Deep or sea water channels.

In the year 1901, arising from a Royal Commission of Inquiry, a scheme was put forward to control the area shown on the plan by training walls and by this method the principles which govern the flow of the tidal Thames from Teddington to the Chapman Lighthouse were to be extended by half-tide revetments into the sea and the entire main approach channel brought under regulation with the assistance of dredging to be undertaken after the walls or revetments were constructed. Owing to the exposed character of the estuary and the problems which the scheme raised in relation to cost accompanied by the possibility that dredging alone would be sufficient, this scheme was not favoured by the predecessors of the Port of London. By this decision a large and unnecessary expenditure was avoided.

The highly successful opening of the Gironde Estuary by dredging is a recent achievement which was not available for comparison or consideration in 1922 when after the Great War the Port of London undertook their dredging tasks *de novo*. Our attention had been drawn to the successful completion of the Ambrose dredged channel at the approaches to New York which is devoid of revetments or artificial training walls.

For many years French engineers had adopted the training wall or revetment for the inner part of the embouchure of the Seine, and Liverpool had adopted similar methods for the Mersey. In the estuary of the River Ribble in Lancashire, training walls have been constructed to control the direction, depth and width of the main entrance channel. But the more comparison is made with the Thames Estuary and other seaport estuaries, the more one finds absence of comparative factors whether in range of tide, velocity of currents and other phenomena. For instance, although the mean seaward course of the tidal Thames is East, it has a propensity to hug its northern or left bank in the principal reaches. Whether this is some affiliation remaining from its early connection with the primordial River Rhine and which the present Thames inherits in the seaward flow, it is impossible to say.

We are told by geologists that rivers flowing northwards invariably wash their western banks and those flowing southwards like the Mississippi (below Ohio) frequently wash their eastern bluffs and rarely erode the western bluffs. Lyell and Giekie, famous geologists ascribe this to the rotation of the earth on its axis (Lyell Ch. XIX, p. 276). The deficiency of the rotary motion when a body of water is transferred from a lower to a higher latitude is probably the cause from which this effect operates—but in so far as the tidal Thames is concerned we are faced with more than one scientific paradox when these laws or facts are examined for possible application.

The tidal Thames in its course persistently runs hard on the north bank in Sea Reach before it debouches into the estuary. This causes a deep water frontage there and consequently for several miles jetties have been erected to accommodate deep-drafted ships. These jetties have come to act as groins to prevent further scour of the river bank so that erosion has been arrested for the greater part. At Canvey Island, however, which is the eastern terminal of the Thames river wall constructions where jetties have not until recently been constructed, there has occurred during the last 100 years a northward erosion of 400-ft. by the action of the tidal stream and the river wall has been set back and reconstructed in consequence. This pressure from the tidal stream on the north bank is also connected with the history of the south bank of corresponding cross sections. When the inner main channel of Sea Reach was dredged, the water level was lowered, which exposed more of the Blyth Sand and thus was conducive to its consolidation and further growth. The south bank sands therefore advanced slightly to form the parallel line for the conduit of discharge also regulating the stream line on the flood, and pressing the flow over towards the north.

From ancient charts we find that the tidal river course was at one time more sinuous and that the stream on rounding the Lower Hope Point in its outward course took a penultimate swing to the south and in recurving finally discharged to the north of the present axis line. This northward course accounted partly for the old channel in the Leigh embayment which closed in the 19th century with the straightening and consolidation of the Blyth Sand. This conduit line which now fixes the general line of discharge does not control it after passing the Chapman cross-section where the estuarial bellmouth is reached.

Study of Model

At this stage of the report, the research which was undertaken in 1901 and continued until 1904 should be studied in connection with a model then made of the river and estuary from Teddington to the Nore Lightship. The upper portion of the model was a fixture, at the lower end a flexible joint connected it to a large reservoir which was alternately raised and lowered by suitable mechanism in such a manner that the water contained flowed up and down the river exactly like the true tidal currents. (Cruttwell's Report, 7th January, 1904). In order to make the working of the model as true to Nature as possible, a continuous stream of water was introduced at the Teddington end (70 statute miles from the Nore) and another stream lower down to represent the combined inflow of the various lower streams below Teddington. The horizontal scale of the model was 6-in. to the statute mile and the vertical scale 32-ft. to an inch. The time scale of the model corresponding to these scales by a mathematical law was 1-540th of the natural time. In other words, as many tides can be observed in one day's working of the model as would occur in 540 days of actual time.

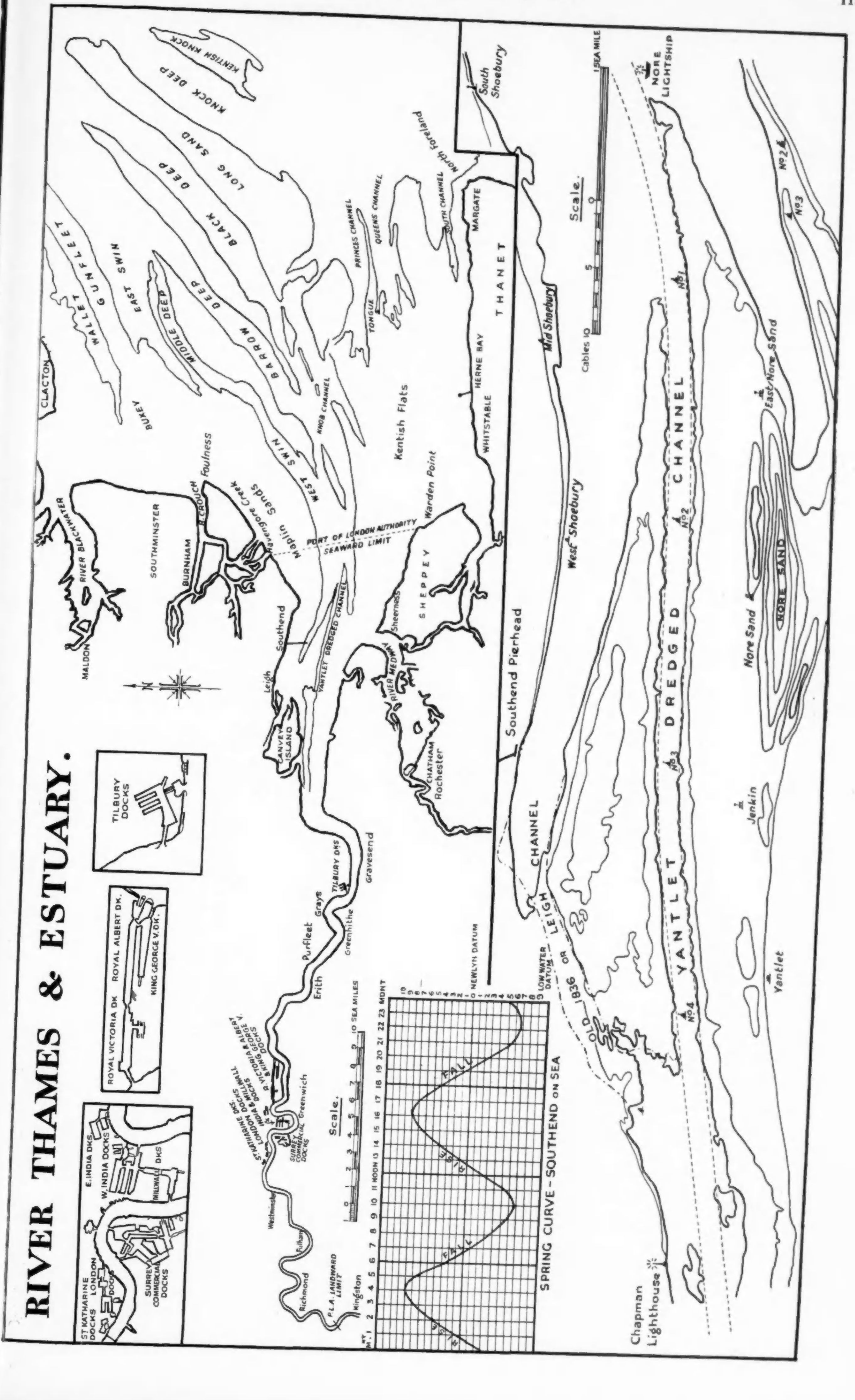
The first series of experiments consisted in running the model for several consecutive days, during which period the velocities and directions of the tidal currents, and the varying periods of flood and ebb at the different points of the river, were carefully noted. Attention was chiefly directed to that portion of the river and estuary between the Chapman and the Nore.

Previous to the making of this model the remedial measures referred to on a previous page had been recommended by which training walls were carried out to sea across the sand banks. By experimenting with miniature training walls on the model, after experiments of free flow had been conducted, a conclusion was reached that the training banks would not be of any material benefit certainly on the alignments and directions proposed. Furthermore, the disproportion of the grains of sand used, notwithstanding a special refining process were found to be too large to be carried along by the currents, so that no actual depositing or shifting of the shoals were discernible. With these elements unproved and the high cost of the training walls which at that time was estimated at £843,280, no further consideration was given to the training wall proposals.

In justice, therefore, to the advocates of estuarial models the mechanical results obtained by this model appear to have disproved the need of artificial training walls as a solution to the problem of a navigable outlet in the bellmouth of Sea Reach. This paper will show that the results 38 years later are such that the rejection of the training walls scheme was fully justified.

Reverting to the dredged Ambrose Channel at New York, it will be observed that the tidal range there is approximately one-quarter that of the Yantlet Channel. This may be regarded as a point in favour of the latter *qua* influx and efflux of the tidal stream. On the other hand the supply of oceanic water which enters by way of Hell Gate through Long Island Sound into New York Harbour, thus adding to the outflow of the Hudson River may be claimed as an asset in tidal circulation for the Ambrose. The following details supplied by Colonel Hall of the United States Engineer Office, show the conditions:—

(1) In a complete tidal cycle having a duration of 12½ hours, it has been estimated that the average flow of water through the Narrows is 12¼ billion cubic feet on the ebb tide and 11 billion cubic feet on the flood tide. The net excess flow out through the Narrows in each tidal cycle is 1¼ billion cubic feet. Long Island Sound empties into New York Harbour on each tidal cycle about 130 million



RIVER THAMES & ESTUARY.
ST KATHARINE DOCKS
LONDON DOCKS
SURREY COMMERCIAL DOCKS
E. INDIA DKS.
W. INDIA DOCKS
MILLWALL DKS
ROYAL VICTORIA DK
ROYAL ALBERT DK.
KING GEORGE V. DK.
TILBURY DOCKS
MALDON
RIVER BLACKWATER
SOUTHMINSTER
BURNHAM
R. CROUCH
Foulness
Havengore Creek
Maplin Sands
PORT OF LONDON AUTHORITY SEAWARD LIMIT
CLACTON
BUXEY
WALLET
GUNFLEET
EAST SWIN
MIDDLE DEEP
BARROW
WEST SWIN
BLACK DEEP
LONG SAND
KNOCK DEEP
KENTISH KNOCK
KNOB CHANNEL
PRINCES CHANNEL
QUEENS CHANNEL
TONGUE
SOUTH CHANNEL
North Foreland
MARGATE
THANET
HERNE BAY
WHITSTABLE
Kentish Flats
Warden Point
SHEPPEY
Sheerness
RIVER MEDWAY
CHATHAM
Rochester
CANVEY ISLAND
Leigh
Southend
YANTLET DREDGED CHANNEL
Gravesend
TILBURY DKS
Grays
Purfleet
Greenhithe
Erith
Greenwich
Westminster
Fulham
Richmond
Kingston
P.L.A. LANDWARD LIMIT
Scale.
10 SEA MILES
SPRING CURVE - SOUTHEND ON SEA
FALL
RISE
NOON
MDNT
LOW WATER DATUM
NEWLYN DATUM
South Shoebury
Southend Pierhead
Mid Shoebury
West Shoebury
Cables 10
1 SEA MILE
NORE LIGHTSHIP
OLD 1836 OR LEIGH CHANNEL
YANTLET DREDGED CHANNEL
No.1
No.2
No.3
No.4
East Nore Sand
NORE SAND
Nore Sand
Jenkin
Yantlet
Chapman Lighthouse

Yantlet Dredged Channel in the Thames Estuary—continued

View of the Thames at Woolwich Ferry.

cubic feet more than it receives. Approximately 100 million cubic feet of this flow, originating in Long Island Sound, passes through the East River to Upper New York Bay and the remainder, 30 million cubic feet, passes north through the Harlem River and thence south through Hudson River before it empties into Upper New York Bay. This total of 130 million cubic feet, which originates in Long Island Sound constitutes about 1/10th of the total excess ebb flow of 1¼ billion cubic feet passing through the Narrows in each tidal cycle. The effect of the tide prism of the East River on the total flow through the Narrows is much more appreciable. Of the total flow through the Narrows approximately one-third of the volume is contributed by the East River. It is assumed, therefore, that the total flow from the East River is responsible for one-third the strength of the current through the Ambrose Channel. It is believed that the principal effect of the flow through the East River on conditions in Ambrose Channel is only to increase the current velocities.

(2) Since the completion of the improvement in 1915 to previously authorised dimensions, 2,000-ft. width and 40-ft. depth at mean low water, the channel has to all intents and purposes maintained itself. The depths in the channel as shown by recent surveys compare quite favourably with those obtained after the original dredging. The channel is practically in a state of equilibrium. One shoal of a minor nature had been formed between buoys 6A and 8.

The River Hudson's flow lies between 1,080 million gallons per day average, and 129,600 million gallons per day in flood. The Thames' flow lies between 300 million gallons per day average and 10,000 million gallons per day in flood.

The success of the United States Engineers in dredging this channel under factors of small tidal range and exceptional curvature were encouraging as far as comparisons with the Yantlet scheme permitted. Let us compare the relevant conditions:—

NEW YORK.

AMBROSE DREDGED CHANNEL.

Material ...	Alluvium and Sand	
Length ...	7.4 miles	
Width ...	2,000 feet	
Depth ...	40 feet (Mean Low Water)	
Tidal Range	4 ft. 6 in.	
Courses ...	2.2 miles 169° outward	A
	4.5 miles 117° ,,	B
Maximum alteration of course ...	A—B 52°	

LONDON.

YANTLET DREDGED CHANNEL.

Material ...	Alluvium and Sand		
Length ...	8 miles (dredged)		
Width ...	1.000 feet		
Depth ...	30 feet (L.W.O.S.T.)		
Tidal Range	16 ft. 10 ins. Mean of Spring Tides		
Courses ...	2.00	92¼° outward	A
	1.72	95¾° ,,	B
Total alteration of course	1.90	103°	C
	1.86	99¼°	D
	1.68	97°	E
	9.16	10½°	A—C = Maximum alteration of course.
Less non-dredged	1.16		
	8.00		

The present dredged Yantlet Channel differs from the Ambrose and Mersey Channels chiefly by its small variation in course alteration for shipping. There are no sharp bends in the Yantlet development.

From data supplied by the Conservancy, the Thames sends into the tideway about 53 thousand tons of silt per annum descending the river by stages to the estuary, a small quantity being intercepted by dredging in the middle reaches.

For some thousands of years this sediment has been carried down stream to form the inner estuarial deposits. As an experiment we investigated the time required for silt in suspension to reach the sea in its 70 miles of tidal course with the following results:

In winter (February) with a mean fresh water discharge during the experiments of 2,350 million gallons per day the time taken for a sub-surface float to reach the sea from Teddington was about 5½ days and during its progress down stream the float covered in the zig-zag of the flood and ebb tide a distance of 202 miles.

In summer (June) with a mean fresh water discharge during the experiments of 577 million gallons per day the time taken for a sub-surface float to reach the sea from Teddington was about 19 days—approximately four times longer in transit than in winter and during its progress down stream the float covered in the zig-zag of the flood and ebb tide a distance of 844 miles.

The lunar conditions and tidal selection were similar and both floats were placed at Teddington the tide head and starting point at High Water.

It is known that nature tends to augment the development artificially created in such dredged tidal channels, provided the alignment or curvature is satisfactory. Proof of this axiom is found in the Yantlet which now has definite features for natural preservation:—

(1) That the dredged cut for the greater part of its length lies parallel to the alignment of the elongated 24-ft. banks on either side of it.

(2) That at its seaward end the curve is in conformity with the strong tidal stream running to and from the West Swin and Barrow Deep.

Arguments were advanced in the early days of discussion that a straight cut across the banks should prove to be successful on the principle that a projectile passing through a straight tube would be travelling in the direction of maximum energy. But tidal energy is sinuous and may be discontinuous, so that retention of the sinuous watercourse recognises the energising forces in the tidal cycle peculiar to each locality. It became apparent on study of the tidal stream that the vigorous flood stream would sweep past any entrance placed transversely to it and would not feed it. Moreover, the early experiments made went to prove that if a straight East-West cut were made the mouth would be again silted up by the contours asserting their formations at the mouth. Next, our study was devoted to the avoidance of convex and concave bends in the dredged channel. Previously we had experience in the upper reaches in the waterway of this tidal-hydraulic phenomenon and its variants. We in fact discovered that within limits related to the fall of the channel bed if a change of direction

Yantlet Dredged Channel in the Thames Estuary—continued

less than ten degrees in channel curvature can be secured then no appreciable convex-concave formations will develop.

In the curvatures of the Yantlet Channel the several changes of course are gradual and consecutive changes, of course, are less than ten degrees in variation with beneficial hydraulic results. As to gradient: The bed of the tidal Thames between London Bridge (which fixes the river bed navigation upper zero) and Gravesend, falls approximately one foot to the mile. The lowest low water occurs at or near King George V Dock in Galleons Reach midway between London Bridge and Gravesend. This fall of the river bed is naturally related to the parallel land levels which required close examination in order to examine and eliminate error in land level and tide level. In this research we had at our disposal the remarkable work of Mr. Lloyd who had been employed in levelling the Isthmus of Darien. Mr. Lloyd levelled the south bank of the Thames tideway from Sheerness to London in the years 1827-28-29. This work was published in the transactions of the Royal Society of London in 1830 and consisted of a line of levels stretching along the south bank of the tideway for a distance of about 40 miles. During the three years which occupied his time in levelling often interrupted by weather conditions he conducted a complete series of sea-level observations at Sheerness. In his report he states that he found a difference of 0.556 of a foot between the mean level of neap tides and that of spring tides; but as the whole of the year 1827 presented the most perfect year of observations, he took that year's mean for a standard.

There followed in the years 1840-1860 the primary Government levelling of England and Wales which enabled the levels of Mr. Lloyd to be joined to the north bank. Further, in 1919-1921 came the second Government geodetic levelling of England and Wales. Between 1830 and 1921 the Thames Tidal levels had considerably changed, due to the excavation of approximately 60 million cubic metres of solid material from the course by dredging. These tidal changes were affecting the low waters and high waters over the entire regime of the river. Nevertheless the early datum levels on the land at Sheerness which is at the mouth of the river proved of considerable assistance in building up the relation between range and phase and were of the greatest assistance to us in balancing the values of low water spring tides, the datum to which our dredging is taken and in co-relating the change which has occurred in the times of high and low water with increase of range and other factors in 100 years.

The work of the Second Geodetic levelling of England in 1919-21 levels gave us accuracy for both sides of the river mouth which the earlier figures could not supply, so that the dredging plans were on a sure foundation.

Having secured the correct datum for dredging, the next problem was to consider the best possible route for the discharge comformable to nature.

In the western section where Sea Reach Buoy No. 3 is now situated the early surveyors' charts showed an elongated pool which retained its situation and character notwithstanding considerable changes elsewhere. This pool formed the key point or axis for the designing of the channel through the sand banks and was associated with the stream line of the ebb discharge.

Sea Reach at this area shows three flood formations: On the north, the Warp—a deep cul de sac terminating near Leigh Creek; on the south, the Great Nore—also a deep cul de sac; in the centre, the area of the Yantlet flats where the dredged channel is now situated.

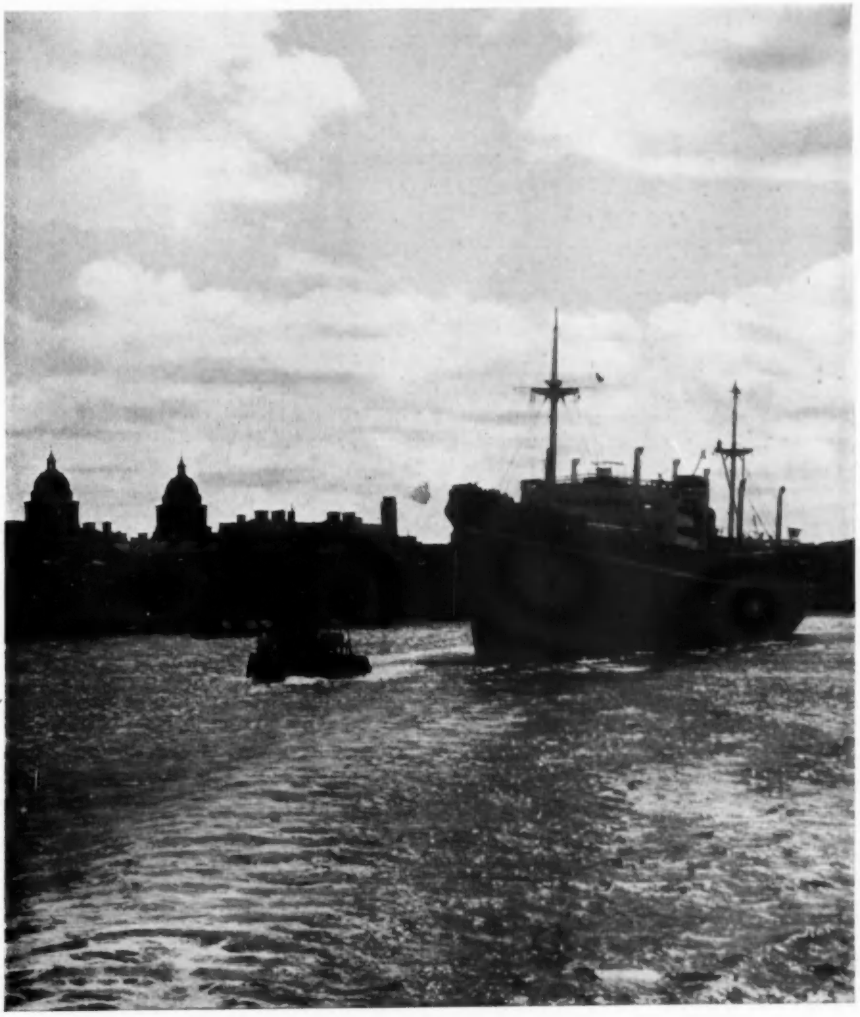
Surveys made by Admiralty Surveyors between 1775 and 1895 showed variation in the shape of the Yantlet banks with a tendency as time went on to congestion and siltation, probably due to the estuary receiving accumulations of detritus and sewerage from an increasing population and the development of industry.

The features of these surveys were as follows:—

1775 Murdoch Mackenzie	Mid-estuary channel with narrow central drainage. North (Leigh) navigation channel closed.
1836-1841 Captain Bullock	Mid-estuary channel narrow irregular pools instability evident over broad areas.
1863 Captain Bullock	North (Leigh) navigation channel open and deep. As for 1836/41 but showing deterioration. Loss of depth in mid-estuary and in north channel.
1894-1895 Captains Pirie and Jarrad	Further deterioration in depth generally, but a pool remaining at the present position of No. 3 Buoy.

We therefore had accumulated the following fundamental information:—

(1) General knowledge of geological formations.
(2) History of hydrographic surveys for approximately 150 years.
(3) Consideration of the experiments with mechanical models inforecasting estuarial behaviour.



Thames at Greenwich.

(4) Comparison with other estuarial dredged channels where training walls were absent, with special reference to the Ambrose Channel.
(5) Precise datum levels from land surveys to establish tidal accuracy.

There remained essential hydrographic data to eliminate trial and error as far as possible.

This hydrographic research required fell under the following details:—

(1) Testing of the nature of river bed by snapper-lead, followed by soundings, charting, contouring methods.
(2) Tidal research.
(3) Surface currents, their direction, duration and force.
(4) Ground currents, their directions, duration and force.

Charts, Soundings, Contouring, etc.

Since the commencement of the surveys by the Port of London Authority, charts of Sea Reach have been drawn to the same scale as the surveyors' sheets (6-in. to statute mile). For accuracy a special triangulation was undertaken to remove primary inaccuracy and north and south banks have also been well-co-ordinated by azimuth.

Soundings have always been taken by means of a manganese bronze wire marked every 6 inches on the hand lead system. In recent years this method has been supplemented by the Echo Sounder. The nature of the river bed was explored to verify its quality and for this work a snapper-lead was used. This implement saves dredging when it is desired to obtain a sample of the bottom. It consists of a heavyweight sliding over a tube with two brass

Yantlet Dredged Channel in the Thames Estuary—continued

spoons at its base, these being kept open by a set spring until the weight falls on the river bed, the spoons close, and bring a sample to the surface.

By this method a complete series of surface bed samples were obtained which showed that the material was too fine and flocculent for sand pumps, but ideal for bucket dredging. These determinations were continued seaward until the sand and shell of the littoral drift were encountered.

We found that the deposits laid down by the Thames and those of the littoral drift were easily identified.

Geologically, the lower Thames basin is not difficult to dredge, the following being the over-lay on chalk:—

1. Alluvium—Modern to the Bronze Age and post Roman deposits 45-ft. thick.
2. Clay and Peat—Neolithic—2000 B.C.; Mesolithic—3000 B.C., 40-ft. thick.
3. Gravel—Pleistocene—about 15-ft. thick, lying about 30-45-ft. below Low Water.

The variations of the current in the modern tideway have removed most of the Bronze Age and Mesolithic deposits, so that the modern sewage-laden detritus now lies on the surface.

Tidal Research—Southend-on-Sea

(a) The range of tide at mean springs = 16.8-ft.
(b) The range of tide at mean neaps – 10.8-ft.
These ranges are taken at the seaward end of the dredged cut, where also the tidal stream observations were taken.
(c) Period of slack water at Nore Lightship.

From a series of observations occupying forty-four high water periods and forty-three low water periods the period of slack water from surface to ten feet below surface was found to be nineteen minutes.

Southend-on-Sea—Tidal Levels

Datum of Soundings Zero O (also 20-ft. below Thames High Water Level).

		ft.	ins.
Lowest Recorded Level	–	3	3
Mean Low Water Spring Tides	+	1	1
Mean Low Water Ordinary Tides	+	2	6½
Mean Low Water Neap Tides	+	3	10
Mean Tide Level	+	9	4½
Mean High Water Neap Tides	+	14	8
Mean High Water Ordinary Tides	+	16	4½
Mean High Water Spring Tides	+	17	11
Highest Recorded Level	+	22	6

N.B.—Tides referred to as Ordinary Tides are a computation and mean of all tides.

Tidal Constants

Based upon time of High Water and Low Water at London Bridge.

	Subtract
High Water, Southend	1 hr. 26 mins.
Low Water, Southend	1 hr. 56 mins.

on Spring Tides.

It is therefore High Water at Southend 1 hour before King George V Dock, which is 10 miles seaward of London Bridge.

Surface and Ground Currents

Behaviour of Flood Tide Currents

As previously described, the *surface* currents on the flood tide strike the apex of the Yantlet Channel banks and split into three parts. One part continues a northerly curved course close to Southend Pier, filling the cul de sac on the north side of the estuary. The second curves southward filling the Great Nore pocket and also the River Medway. The third or middle branch flows into the Thames Estuary with considerable vigour, but does not have complete unity of direction until No. 3 Buoy is reached. Before reaching this position the surface currents vary from the mean or centre line of the tide by 5 to 10 degrees.

Behaviour of Ebb Tide Currents

On the ebb tide the *surface* currents debouche first on lines parallel with the threads of the under-current and dredged channel. Secondly, as the ebb tide gains momentum the stream takes a northerly run following the receding main tidal ebb through the West Swin and Barrow Deep. This run to the north may be as much as 18 degrees from the dredged channel alignment, but usually is less, about 8 degrees.

As the tide falls the higher banks become depleted of water and the drainage area of the dredged channel draws the tributary currents towards it so that during the last quarter of the ebb tide the stream runs mainly in the dredged cut following the curves of the alignment.

Method of Observing Surface and Ground Currents Data

In order to obtain (1) the direction, (2) duration, (3) velocity, (4) period of slack water, together with the continuous and discontinuous stream lines we have found the box-kite float the most advantageous. For this purpose a buoyant wooden frame measuring 4-ft. long by 2-ft. square is covered with canvas and immersed to the required depth, weighted so as to retain sufficient buoyancy and so remain at the level decided. If curface currents are being measured the float is kept under water sufficiently to escape wind pressure—the float having a small flap incapable of collecting the wind.

When ground currents are being measured the canvas box float is weighted until buoyancy just essential for floatation 1-ft. above sea bed has been obtained. The surface indicator is connected to the submerged box float by a fine wire and consists of a thin pole carrying a small flag incapable of pulling the ground float by the greater velocity of the surface current

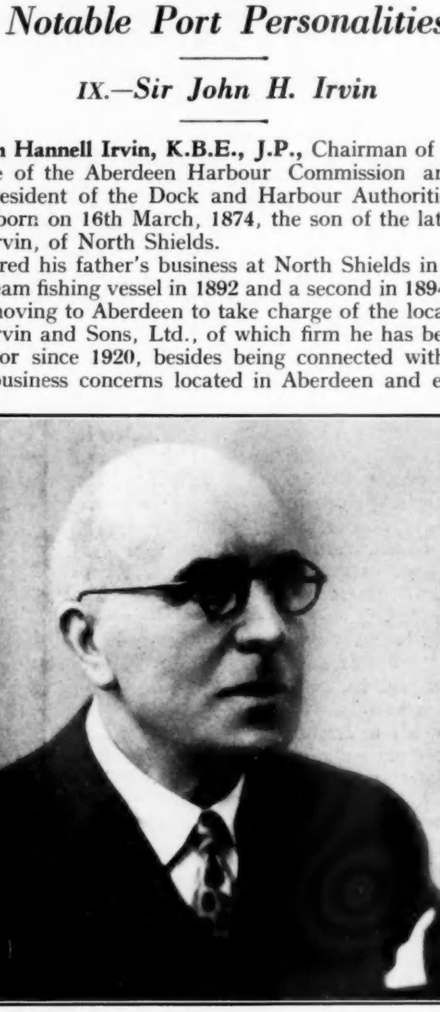
(To be continued)

Notable Port Personalities

IX.—Sir John H. Irvin

Sir John Hannell Irvin, K.B.E., J.P., Chairman of the Finance Committee of the Aberdeen Harbour Commission and recently elected President of the Dock and Harbour Authorities' Association, was born on 16th March, 1874, the son of the late Alderman Richard Irvin, of North Shields.

He entered his father's business at North Shields in 1887, built his first steam fishing vessel in 1892 and a second in 1894, thereafter in 1895, moving to Aberdeen to take charge of the local branch of Richard Irvin and Sons, Ltd., of which firm he has been Governing Director since 1920, besides being connected with a number of other business concerns located in Aberdeen and elsewhere.



SIR JOHN HANNELL IRVIN, K.B.E., J.P.

During the war of 1914-18 he rendered effective assistance in an advisory capacity to the Blockade Ministry and was captured on the high seas while on Government business, being interned in Germany from 1916 to 1918. He has held a number of offices on various shipping associations and public bodies.

His official connection with the Port of Aberdeen commenced in 1902, when he was appointed a Commissioner of the Harbour. In 1911, he became Chairman of the Finance Committee and has continued to act as such until the present time. He became Chairman of the Port Emergency Committee in 1939. He has represented the East Coast of Scotland ports in the Dock and Harbour Authorities' Association during several periods, viz.:—1927-9; 1934 and 1936-7. At the last general meeting of the Association, he was elected to succeed Lord Ritchie in the Presidency.

Sir John was knighted in 1917. There are port traditions in his family. His father, Alderman Richard Irvin, was for many years a member of the River Tyne Improvement Commission, and since his death, his brother, Alderman Richard Irvin, has been a member of the same Commission.

The St. Lawrence Deep Waterway Scheme.

Representatives of Canada and the United States have recently signed a new agreement to begin work on the St. Lawrence navigation and power project.

Notes of the Month

Port of Bristol Authority.

Mr. F. D. Arney, formerly secretary and assistant to the general manager of the Port of Bristol Authority has been appointed Assistant General Manager of the undertaking. He has been in the service for the past 27 years.

New Floating Dock for Canada.

A new floating dock capable of accommodating the largest ships in the British Navy, is to be provided at an Eastern Canadian port. The contract has been placed at a cost of between 2½ and 2¾ million dollars and the dock is to be completed and ready for service in 1942.

Convoy Work During 1940.

During 1940, over two thousand convoys of shipping totalling 40,000 vessels, with an aggregate of some 200 million tons of cargo, were escorted by aircraft of the Coastal Command in co-operation with the Royal Navy. The value of the cargoes is estimated at £4,000,000 per day.

Coleraine Harbour Dredging.

The Minister of Commerce for Northern Ireland has intimated to the Coleraine Harbour Board that, after a review of all the circumstances, he regrets his inability to increase the offer of £9,500 which he made towards the cost of dredging work required to be carried out in the harbour.

Blyth Harbour Commission.

At the annual meeting of the Blyth Harbour Commission, Colonel N. I. Wright was elected chairman in succession to Mr. W. Rushforth. The statement of accounts for 1940 was presented and it was stated that despite war-time conditions, there had been no increase in port dues.

Increase of Equipment at Canadian Ports.

Col. A. E. Dubuc, vice-chairman and chief engineer of the Canadian National Harbours Board has announced that the equipment of the harbours of Saint John and Halifax is being augmented in order to relieve congestion and to cope with the congestion due to war-time traffic. It is also contemplated to reconstruct the McLeod and Pettinghill wharves at the Port of Saint John.

Shipping Returns at Los Angeles.

According to returns emanating from the Maritime Exchange of the Chamber of Commerce of Los Angeles, California, U.S.A., the total weight of exports and imports at the port during 1940 was 5,102,843 tons, valued at $223,110,079, as compared with 6,697,684 tons in 1939, valued at $216,431,350. Shipping arrivals at the port were also lower, numbering 5,493 vessels of 17,765,401 net tons, as against 6,109 vessels of 19,932,440 tons during the previous year.

River Wear Commission.

Mr. Stephen Furness, M.P. for Sunderland, has been appointed a member of the River Wear Commission by the Minister of Transport to fill the vacancy caused by the death of Sir Luke Thompson. Alderman Frank Nicholson has been re-elected chairman of the Commission for a further term of three years, and Mr. T. W. Greenwell has been re-elected vice-chairman.

Directorate of Ports Appointments.

The following appointments have been announced in connection with the creation by the Ministry of Transport of a Directorate of Ports: Mr. P. H. Tolerton, a principal assistant secretary at the Ministry, has been nominated as Director of Ports, Mr. S. S. Wilson an assistant secretary, Deputy-Director, and Mr. R. P. Biddle, Docks and Marine Manager at Southampton, Assistant Director. The first two gentlemen have been responsible during the past two years for the port and transit organisation at the Ministry of Transport.

Ocean Current Drifts.

It is stated in the Washington Hydrographic Bulletin that among the bottle papers received. one thrown overboard by an observer in lat. 00 23 S., long. 35 45 W., on May 16th, 1940, was found on December, 14th, 1940, on the coast of British Honduras in (approximately) lat. 16 58 N., long. 88 13 W., having drifted about 3,350 miles. One thrown overboard in lat. 28 00 N., long. 79 35 W., on November 28th, 1938, was found on December 4th, 1940, on Sao Miguel Island, Azores, in (approximately) lat. 37 44 N., long. 25 35 W., having drifted about 2,850 miles. Another thrown overboard in lat. 45 15 N., long. 25 25 W., on July 7th, 1939, was found on the Island of Martinique, West Indies, on December 18th, 1940, in (approximately) lat. 14 33 N., long. 60 51 W., having possibly drifted about 4,600 miles.

Dock Company's Increased Profit.

The report of the directors of Smith's Dock Company, Ltd., for the year ended 30th September last shows a profit of £437,282, which is a substantial further increase on that of last year, viz., £274,197.

Welland Ship Canal Traffic.

Traffic on the Welland Ship Canal, connecting Lake Erie with Lake Ontario, established a new record during the 1940 navigation season, when 12,909,597 tons of freight passed through the locks. This was 9.5 per cent. higher than the 1939 tonnage.

New Dock Board Member.

At a recent meeting of the Mersey Docks and Harbour Board, Mr. Montague Arnet Robinson, general manager of Coast Lines, Ltd., was appointed an elective member of the Board to fill the vacancy caused by the death of Mr. Maurice H. Hulme.

New Transit Shed at Long Beach.

During the coming year a new transit shed is projected at the Port of Long Beach, California, U.S.A. It will have an area of 125,000 sq. ft. and the cost, inclusive of contingent improvements in the vicinity is estimated at $300,000.

Dredging at the Port of Tientsin.

The Commissioners of the Hai Ho Conservancy Board, China, announce that during the month of October last, 139,648 cu. yds. of spoil was dredged from the river. Heavy silting deposits caused by wave action during strong North-westerly winds has interfered with the effective progress of the work.

Manchester Ship Canal Company.

The Statement of Accounts for the year 1940 submitted to the Meeting of the Shareholders of the Manchester Ship Canal Company on 28th February showed net receipts of the whole undertaking as £1,133,445 and net revenue as £869,462. After deduction of interest and other charges, and dividends there is a carry forward of £25,269.

Mersey Port Dues.

The Mersey Docks and Harbour Board have made increases in rates and dues in order to meet growing expenditure. The increases are (a) 33⅓ per cent. in dock tonnage and wharf rates on vessels and in dock rates and town dues on goods; (b) 15 per cent. on harbour rates on vessels in lieu of the reduction of 20 per cent. at present in force.

Port Labour Employers' Council.

Mr. R. T. Garrett has been elected chairman of the National Joint Council of Port Labour Employers. Mr. Garrett, who is a director of Anderson, Green and Co., Ltd., managers of the Orient Line, is a member of the Port of London Authority, and has been associated for many years with the dock labour industry. Mr. A. H. Bibby of Liverpool, and Mr. James S. Spencer of Glasgow, have been elected vice-chairmen of the Council.

Port of Houston Ship Channel.

The widening and deepening of the ship channel leading to the Port of Houston, Texas, is rapidly nearing completion. The standard depth will be 36-37-ft. with a minimum bottom width of 200-ft. There remains only a length of 2½ miles below the Turning Basin to be dealt with and the contract for this work has been placed.

Belfast Dockers' Working Hours.

Following an award of the National Arbitration Tribunal, Northern Ireland, an agreement has been entered into between the L.M.S. Railway Co., Ltd., and the Amalgamated Transport and General Workers' Union on the hours of work of dockers engaged at the Heysham Shed, Belfast. A readjustment of shifts is provided for in the agreement which does not prejudice arrangements in force under normal conditions.

Proposal for Swedish Canal.

Arising out of war-time difficulties and as a means of providing an inland route across the South of Sweden for vessels larger than those which can use the Göta Canal route through Lake Vättern, another canal is under discussion, the Svea Canal, to connect Lake Mälaren with Lake Vänern via Lake Hjälmaren. The proposal is mooted with a view partly of meeting the unemployment problem, but exception is taken that the industrial activities of Sweden are built up on sea communications rather than on inland water transport. The only heavy inland traffic is timber, which is floated down rivers and streams to the coast. The amount of sea-going tonnage which uses the existing canal system is comparatively small.

The Deterioration of Harbour Structures

Being the Major Portion of the Presidential Address of Mr. P. E. GOLVALA to the Bombay Centre of the Institution of Engineers (India), December, 1940

The earliest waterfront structures were built of untreated timber and in some harbours, these still prevail, but in many places its use has proved disastrous.

There are two main causes of timber deterioration: members in direct contact with sea water are exposed to the ravages of marine borers while others decay from exposure. The former consist mainly of pile supports, braces extending below water line and bulkheads, the latter of decks and fender heads of piles, which are alternately wet, and dry, and that part of the bulkhead exposed to earth filling.

Timber below water level in salt water and to a very limited extent in fresh water, is subject to attack by molluscans—related to the oyster and the clam—and the crustacean—related to lobster and the crab. The notorious "shipworm" or *Teredo navalis* is typical of the first group.

The crustacean group consists of *Limnoria, Chelura* and *Sphaeroma,* but they are less dangerous than the molluscans. Unlike the other group, they attack the outside of the timber so that if the structure is regularly inspected there will be no possibility of collapse.

Stone masonry is used in quays, piers and dry dock construction and is very durable if the stone is good but the limestone is not as durable as granite or a dense sandstone and is more subject to attack by marine borers of two types. One, the group of *Pholads,* is widely distributed. It bores mechanically and may attack any type of stone; the other, which acts through a chemical dissolving agent, is not dangerous except to limestone.

The use of mass concrete and especially reinforced cement concrete in harbour structures has steadily increased during recent years. Exposure of concrete must always be considered in design. Though mass concrete and reinforced concrete are standard materials for fresh water, exposure to sea water imposes a greater risk of deterioration and disaster and materials must be selected with the utmost care. The effect of alternate freezing and thawing, of drifting ice, of the impact of heavy seas introduce different cumulatively formidable problems.

Cast iron does not corrode in sea water as wrought iron and steel do, but its composition changes very gradually to graphite; it is brittle and liable to be broken by shock either by driftwood or vessels. The Mazagon Pier, the old landing place for English mail boats in Bombay, built in 1870 at a cost of Rs. 2,19,000 of cast iron piles and wrought iron girders and floor plates has given long service, but during the recent cyclone vessels struck against it breaking five piles.

Wrought iron is also a suitable material in spite of its initial cost. An 8-in. diameter pile in a harbour structure built in 1872 in the Port of Madras was found in 1921, i.e., 49 years later, to have been reduced to 7-in. diameter.

Steel is the least durable and is generally seriously worn out after 20 years or so. Piles and braces of the steel structures of Berth No. 7, at the Port of Karachi, when inspected after 30 years, were found to have lost 22 per cent. of section by corrosion. A better example is of the landing stage at Weston-super-Mare, a piled structure built mainly of rolled mild steel sections, opened in 1908, and dismantled in 1922, after only 14 years' use. The stage was satisfactorily erected and was in constant use from 1908 to the end of 1921, although its maintenance was a source of trouble. The first sign of insecurity was that the bolts appeared to be loose though externally no signs of deterioration could be detected. On applying a spanner the outer skin of the nut broke down to a wet pasty mass, a mixture of hydrated oxides of iron. The shanks of the rivets had deteriorated and worked loose and were reduced in section at the point of contact with adjacent plates. Subsequently the piles fractured and the pier was closed to traffic in January, 1922, and dismantled. On that same landing stage fendering of oregon pine logs were proved to have been destroyed by the *Teredo* in only 12 years.

Methods of Timber Protection

There are three methods of protecting timber; covering it with some impenetrable material, using timber which is not attacked and treating it with a toxic substance.

Preserving timber by non-ferrous metal sheathing is a very old method but is expensive and the sheath is liable to be stripped off by harbour thieves. Also even if only a small hole is left anywhere, marine borers will get in and destruction will proceed out of sight. Paints used with a fair measure of success have an asphalt base, but they afford only temporary protection. Timber piles have been encased in concrete but with variable results; the concrete is subject to attack by sea water and is often cracked by impact inseparable from harbour structures. In recent times another method has been tried. Timber piles, before driving, are wrapped with wire fabric and covered with mortar applied with a cement gun. Cast iron casings have also been tried but are very expensive and cannot be easily applied to bracings.

The most universal and dependable protection for timber piling consists of a pressure treatment of coal tar creosote. Timber impregnated with creosote is found to be resistant to *Teredo* in many ports, but creosote gives no protection against *Martesia* and often fails against *Limnoria.* Zinc Chloride, Sodium Fluoride and some salts of copper are also good preservators when used under suitable conditions. Modern research has produced many new substances highly toxic to marine borers.

There is no easy or obvious safeguard. Piles have been studded with iron, copper, zinc, and brass nails; sheathed in lead, brass, copper, non-ferrous alloy, iron and steel; surrounded by planking, concrete, earthenware or cast iron piles; they have been cement gunned, plastered, painted, charred, compressed and vulcanised; dipped in, boiled in and impregnated with, alcohol, creosote, petrol, kerosene, fuel oils, ammonia, crepe rubber, tar oil, rubber latex, sulphur, silica gel, cellulose, dyes of all kinds, and literally hundreds of different poisons. They have even had electric currents passed round them in the hope that the chlorine liberated by the electrolysis of the sea water would prove destructive to borers. Were it not for its persistent vulnerability timber would be an ideal material, easy to work with, resilient to shock and easily repaired.

Masonry and Concrete

Masonry and concrete are protected externally and internally, the first by plastering, by hand or under pressure by a cement gun. The second method is cementation or pressure grouting. It has been successfully employed in closing off the flow of water through tunnels or leaks in masonry dams, in making doubtful foundations solid and rendering dry and workable flooded pit shafts.

The process consists in injecting through previously drilled holes a mixture of cement and water at a moderate pressure, the result being that successive layers of cement are deposited, the excess water being squeezed through a greater thickness of cement filter, until finally the fissure is completely filled with cement, with just sufficient water to produce the best conditions for good and quick setting.

With metal structures the preservation of metal and the first application of preservating coating is of vital importance. The parts most liable to corrosion and decay are the joints of members and particular attention must be paid to them. Bitumastic enamels and solutions are now widely used and when properly applied give very good results in underwater works and preserve them in a working condition.

Port Labour on the Clyde

Ministry of Transport Scheme

Owing to the complexity of the problems created at the docks by the war, it is announced by the Clyde Regional Port Director, Mr. R. Letch, that in order to speed up port operations, the Ministry of Labour will in future be the employer of all dock labour in the Port of Glasgow. The men are to be engaged on a guaranteed wage basis and, as far as possible, the work will be performed on piece-work terms. It is hoped in this way to create a regular and mobile force of dockers and to relieve the congestion which occurs when the heavy daily volume of traffic is dealt with.

The three main features of the scheme are "(1) co-ordinating the port and transport arrangements; (2) increasing the speed of operations and (3) full co-operation between the various organisations and close co-ordination of the demands upon transport and of the resources for meeting these demands, in order to secure the most economic and effective use of available facilities."

The scheme as outlined above, is incorporated in a memorandum which has been presented by Mr. Letch to Mr. W. Cuthbert, chairman of the Glasgow Port Emergency Committee, with a request to bring the scheme into operation as an instruction made on behalf of the Ministry of Transport under the Control of Traffic at Ports Order, 1939, and to issue the necessary instructions to all concerned.

A Port Transport Executive has been formed, consisting of the chairman and deputy-chairman of the Clyde Navigation Trust, the harbour master, the traffic superintendent and assistant traffic superintendent, movement officers representing the Ministry of Food and Ministry of Supply, storage officers representing the Ministry of Transport, and representatives of the Ministry of Shipping, the London, Midland and Scottish and the London and North-Eastern Railways, and the Glasgow Docks Cartage Organisation. The executive are meeting daily and they discuss all matters affecting the docks and ships. They plan in advance the best use of the transport facilities. They have power to order the removal of goods to an emergency warehouse at the risk and expense of the consignee if he does not effect a speedy removal of his goods from the quayside.

The dock cartage organisation is to act as a clearing house for dock cartage orders, and its first aim will be the effective clearance of the docks. The organisation is intended to include all the cartage firms in or near Glasgow carrying traffic to and from the docks, and also firms of manufacturers, merchants and warehouse-keepers in Glasgow, whose dock traffic is considerable and who use their own vehicles for the traffic.

The Prevention of Coast Erosion*

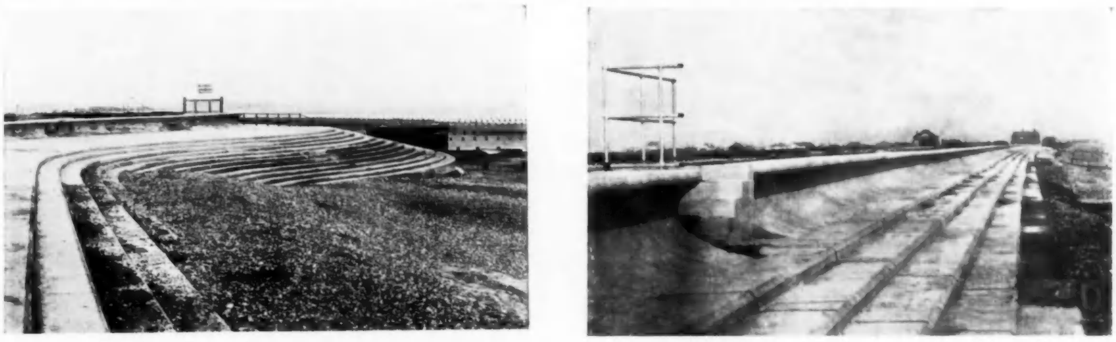
By Francis Maurice Gustavus DU-PLAT-TAYLOR, M.Inst.C.E.

Introduction

IN the British Isles erosion is continuous in some parts of the coasts, notably in the east, whilst accretion is taking place in other parts, such as the North-west. It was stated before the Royal Commission on Coast Erosion in 1911 that, over a period of 25 years, the loss has been 31,000 acres and the gain 30,752 acres. Owing to preventive measures it is certain that the rate of loss has been much diminished since that date; but the fact remains that the loss is usually of good agricultural land, and sometimes buildings, whereas the gain is only of sand and shingle.

In Holland, labyrinths of projecting timber stakes are frequently driven at about mean tide-level, either in the beach or in the seaward slopes of pitched embankments. These are intended to break up the waves, and they are very effective. Many of these labyrinths are to be seen in the Island of Walcheren, where they are inoffensive as regards access to the sea, since the population there is sparse.

Where, however, urban areas have to be protected, it is not usual to rely on earthen embankments or on timber works, and some form of stone or concrete wall is generally adopted. Such sea-walls were formerly made with a vertical or slightly battered face, and many examples may be seen at seaside towns. Such sea-walls can be successful only where the regime of the beach is maintained by groyning, as the undertow resulting from the wave-stroke against a vertical wall in an on-shore gale will speedily remove the sand or shingle in front of the toe of the wall to a great depth, and if this is not restored by the action of the groyning, a collapse may ensue.



Figs. 1. Stepped Type of Sea-Wall at New Romney, Kent.

Large artificial gains have been made by reclamation, such as that of the Zuyder Zee abroad, and at Dublin, Southampton, and elsewhere in the British Isles; but these notes are not concerned with this class of work.

Measures to stop erosion include sea walls (whether merely earthen embankments or structures of timber, stone or concrete), groynes, or planting.

The Author does not propose to deal with planting, which is a very wide subject and as to which it is usual to consult botanical specialists in any particular case.

Sea Walls

In agricultural districts an earth-bank is the usual form of sea-wall, and hundreds of thousands of acres in the Thames Estuary, on the Wash, and elsewhere, are thus protected.

The standard Thames sea-walling is of clay, or earth faced with puddled clay, on which block chalk is pitched 6 or 8-in. thick. It has a seaward slope of 1 in 2 and a rearward slope of 1 in 1, and the width at the top is usually 6-ft. The crown is kept up to the statutory levels of 18 to 20-ft. above Ordnance Datum. Much of the walling dates from Roman times.

In Holland, a much flatter slope is adopted for the embankments, varying on the seaward side from 1 in 3 to 1 in 12. The banks are formed of sand, protected by basalt pitching up to 15-in. thick, pinned down by short piles or stakes. The landward slopes are usually covered with stone, stake, and wattle-work or straw-thatching.

Another form of protection is the use of timber breastworks, consisting of sheet-piles driven in the beach, combined with groynes in front. These methods are not much less costly, and are much less durable, than concrete walls; and they spoil the amenities of the beach if it is used by the public.

Walls of this type have been frequently breached, and only those of considerable thickness and with very deep foundations can be considered really safe. The design of such a wall is not comparable to the requirements of a dock or quay wall. In one instance, to the Author's knowledge, the level of the beach in front of a sea-wall was reduced by 11-ft. in one season by a series of on-shore gales.

Furthermore, in the case of vertical-faced walls the waves are thrown up to a great height in gales, and many tons of water descending on the promenades behind them tend to break up the paving or surfacing, so that the material behind such walls may be washed out.

Modern sea-walls are now usually constructed with sloping, or preferably stepped, faces, so that the force of the waves is gradually absorbed in travelling up the stepped slope, and the water is finally turned back towards the sea by a parapet wall with a curved face. The road or promenade is usually situated immediately behind this parapet wall.

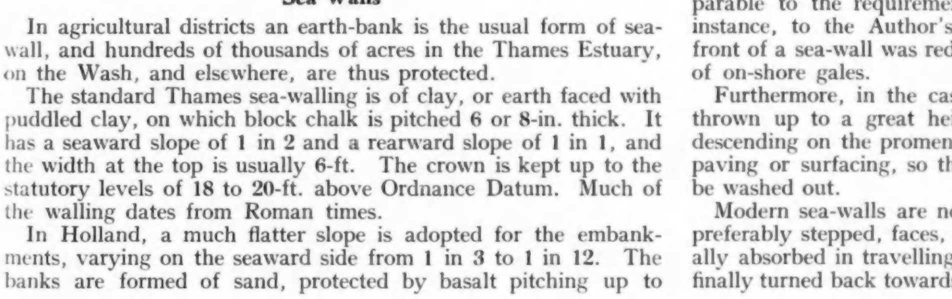


Fig. 2. Cross-Section of Sea-Wall at West Bay, Portrush.

Where space is restricted, this slop- or stepped wall may be surmounted by an open arcade carrying the promenade or road. A recent example of this type of construction will be described later.

Stepped-type walls are usually constructed of reinforced concrete of moderate thickness, with a heavy toe in front, and, to avoid any disturbance of material beneath them, it is always necessary to carry down a curtain-wall, or line of steel sheet-piling, from the toe into some impervious stratum.

Land-water behind the parapet-wall must be dealt with either by a system of drains or by weep-holes in the wall. One advantage of the stepped type of wall is that, in the event of the level of the beach being lowered by exceptional gales at some time subsequent to the construction of the wall, the step-work can be extended to the new level; whereas a vertical wall would have to be under-pinned or rebuilt.

Figs. 1 illustrate a wall of this type, constructed to the Author's designs at New Romney in Kent. The wall is of various widths to accord with variations in the inclination and level of the beach, the total length being about 2 miles. A continuous line of steel sheet-piling, of various lengths, and of copper-content steel, was driven under the toe of the wall into the clay underlying the beach

*Reproduced by permission from the Journal of the Institution of Civil Engineers.

The Prevention of Coast Erosion—*continued*

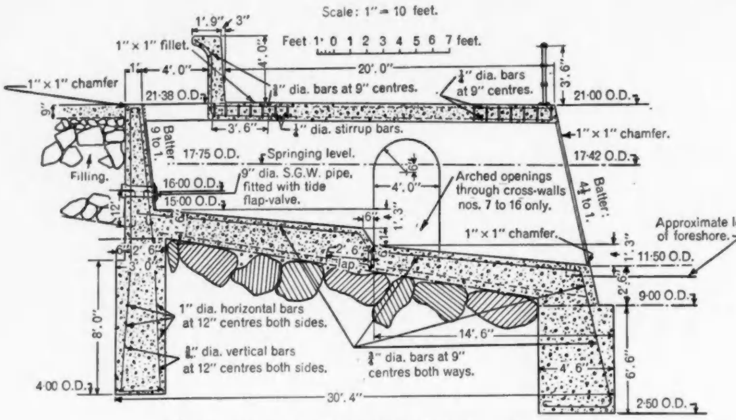


Fig. 3. Cross-Section of Sea-Wall at Folkestone.

material. Case-type low groynes were installed along the frontage.

Fig. 2 is a cross-section of another wall of this type, designed for preventing erosion and protecting a proposed promenade and road at the West Bay at Portrush, Northern Ireland. The length of the proposed wall is 3,300-ft. The conditions there are that, though the bay is exposed to the full force of Atlantic gales, the sand beach is very flat and the low-water mark is a long way out from the line of the wall. The waves are largely absorbed in traversing this wide stretch of sand; hence it has been possible to adopt a light section for the wall.

The width of the wall and the length of the piles under the toe vary at different parts of the frontage, the greatest width of wall being in the centre of the bay.

The erosion at Portrush is of two kinds, sea erosion and wind erosion, both of which attack the sand dunes and slopes at the top of the beach, endangering buildings and roads behind. The wall is intended to arrest sea erosion, and the wind erosion will cease when the area of sand behind the wall is covered with roads, gardens, and house property. The scheme also includes several adjustable screw groynes. Owing to the war, the inception of the work has been postponed indefinitely.

Step-type walls afford easy access to the beach for bathers and others, and this is of importance at seaside places whose prosperity depends largely on the amenities provided.

An example of the arcade type of wall, recently completed at Folkestone in front of the East Cliff, is illustrated in Figs. 3 and 4.

Here, a promenade 20-ft. wide is carried on arches surmounting a sloping and stepped wall. The latter is provided with continuous curtain-walls at back and front, going down to a solid foundation in the Folkestone Beds. At the back of the promenade is a screen wall, 4-ft. high, behind which openings are formed in the deck to allow water thrown over the screen wall to pass back to the sea. The curtain-wall in the rear is carried up to form a retaining-wall behind the arches; 9-in. diameter weep-pipes fitted with tidal flap-valves are provided in this retaining wall in the centre of each arch. The whole structure is of reinforced concrete.

In all long sea-walls of any type it is necessary to provide contraction joints at suitable intervals. These may be straight joints with opposing V-grooves packed with a bitumen and sand composition; or copper-strip joints may be utilised. The former require attention and repacking from time to time. The latter require no attention, but they are more costly.

Groynes

Probably more diverse opinions have been expressed on the subject of groynes than on any other matter, but as to their height and length and to their siting.

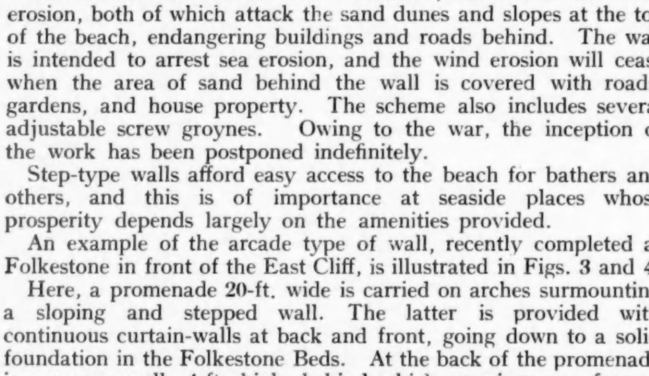


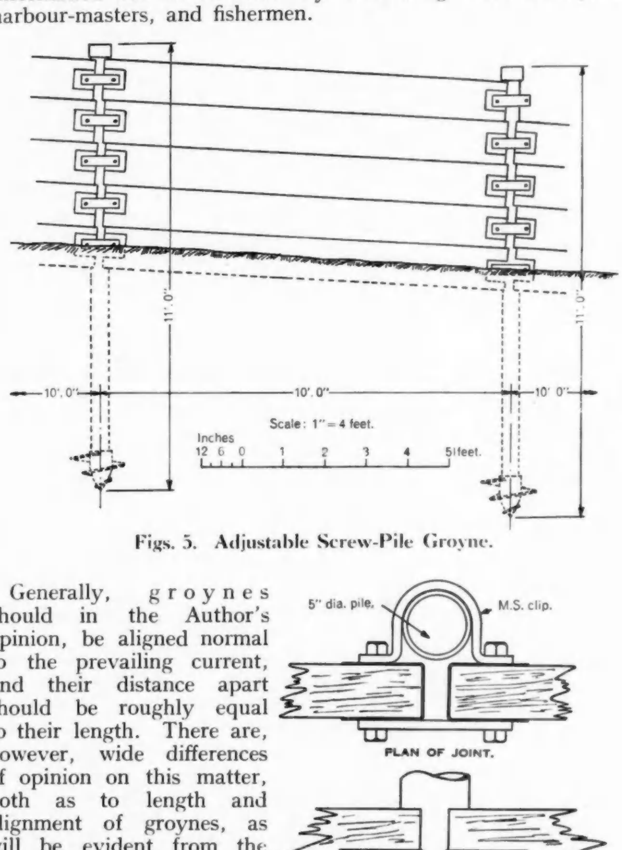
Fig. 4.

In many seaside towns groynes are built of concrete or masonry, and are of a substantial nature and proportionately costly; but, generally speaking, groynes are constructed of timber.

The old-fashioned high groyne with heavy oak spurs still persists in many places. It accumulates material to a great height, and hence there is a deep drop on the lee side, often as much as 15-ft. Thus the beach is accumulated in a series of waves normal to the foreshore line. The low type of groyne produces a much more uniform accumulation, but the groynes must be placed much closer together. In Holland, low stone groynes, built over fascine mattresses, have proved very satisfactory in dealing with the material there, which is exclusively sand. These groynes are 40 to 80-ft. wide, and stand 8 to 10-ft. above the beach-level. In Great Britain, low groynes are usually of the case type, consisting of planking between pairs of posts embedded in concrete. Such groynes are often only 4-ft. high above the beach-level.

Planks can be added between the posts as the beach builds up. When the groyne becomes completely buried, the posts and concrete bases can be dug up and refixed in a fresh position. In one form of low groyne, shown in Figs. 5, screw-piles are substituted for the posts, and the groyne can be adjusted to the beach-level from time to time by screwing or unscrewing the piles by means of a special capstan.

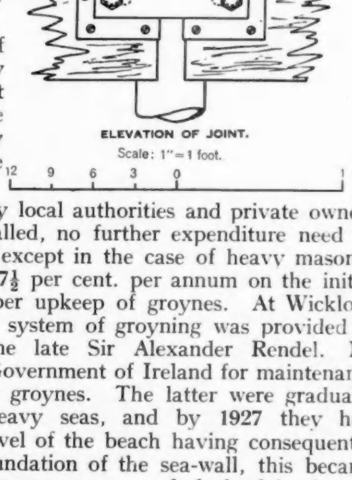
The siting of groynes always requires careful study. If time and money are available, float observations should be made to ascertain the direction of the prevailing currents at various states of the tide; but often this is not possible. Most valuable information can be obtained by consulting local coastguards, harbour-masters, and fishermen.



Figs. 5. Adjustable Screw-Pile Groyne.

Generally, groynes should in the Author's opinion, be aligned normal to the prevailing current, and their distance apart should be roughly equal to their length. There are, however, wide differences of opinion on this matter, both as to length and alignment of groynes, as will be evident from the perusal of many Papers on the subject and handbooks on sea-defences.

The maintenance of groynes is always a heavy item of expenditure, but it is very important, as the stability of a sea-wall may be endangered if the groynes are not kept up.



It is sometimes thought by local authorities and private owners that, once groynes are installed, no further expenditure need be incurred; whereas actually (except in the case of heavy masonry or concrete groynes) about 7½ per cent. per annum on the initial cost is required for the proper upkeep of groynes. At Wicklow, for instance, a sea-wall and system of groyning was provided in 1906 to the designs of the late Sir Alexander Rendel. No provision was made by the Government of Ireland for maintenance either of the wall or of the groynes. The latter were gradually disintegrated by gales and heavy seas, and by 1927 they had totally disappeared. The level of the beach having consequently fallen below that of the foundation of the sea-wall, this became completely wrecked. In consequence a good deal of land, and some houses, have been lost.

In the classic case of Jackson *versus* The Eastbourne Local Board (1884), the plaintiff was contractor for the construction of a sea-wall for the defendants, but not for the construction of

The Prevention of Coast Erosion—continued

groynes. There were some existing groynes, and the plaintiff relied upon the verbal assurance of the defendants' surveyor that these would be maintained and that others would be made. In fact, the groynes were not maintained and no new ones were made; and the effect of this neglect upon the construction of the sea-wall was to lower the beach-level by the sea removing the shingle, in consequence of which a large part of the new sea-wall fell down before the works were completed. The plaintiff sued the Local Board for the cost of maintenance and damages, but lost his case in the House of Lords, on the ground that there was no warranty as to the groynes in the contract.

No contractor in our day would undertake work of this sort unless he was indemnified against the risk of the foundation of the wall being removed by the sea. The action of the sea is capricious and uncertain, and the fact that a beach has maintained its level for 20, 30 or even 50 years is no guarantee that it may not unexpectedly be depleted at any time. Even with suitable and efficient groynes, a series of on-shore gales may remove much beach material into deep water, and, as stated above, a beach was in one instance lowered 11-ft. in one season, though in the two succeeding seasons the original level was restored.

The Author would emphasise that this class of work cannot be compared with dock and harbour work in still waters, and provision must always be made against unexpected conditions arising. Unfortunately there is generally only a limited amount of money available for sea-defence works, which are not in themselves profit-earning. The engineer has therefore so to design the work as to provide the maximum degree of security for the money available, and it is impossible for him to guarantee the permanent security of the works, particularly in cases where he is not made responsible for their maintenance.

The adjustable screw-pile illustrated in Figs. 5 was constructed by Messrs. Braithwaite and Co., Engineers, Ltd.

Dock and Harbour Authorities' Association

Annual Meeting

The Annual Meeting of the Dock and Harbour Authorities' Association was held in Liverpool on 26th February. In the unavoidable absence of Lord Ritchie of Dundee, the retiring President, the meeting was held under the chairmanship of Colonel J. G. B. Beazley, of Liverpool.

The **Chairman** at the outset said that they all regretted not only that Lord Ritchie was unable to be present that day, but also that he had intimated that he could not see his way to permit of his name being re-submitted for election as president, or as chairman of the executive committee. The debt which the Association owed to him was incalculable. He had been chairman of the executive committee for upwards of 11 years, and during the past two years had also filled the post of president of the Association with the greatest possible distinction. Busy man though he had always been, he gave most generously of his time to the affairs of the Association and had on many occasions championed the Association in the House of Lords. All appreciated his great grasp of the many problems which had come before them and the wise counsel he had brought to their deliberations. He was sure it would be their wish that they should record their appreciation and he accordingly moved "That the Association wishes to place on record its sincere appreciation of the great services rendered by the Right Hon. Lord Ritchie of Dundee over a long period of years. The members cannot be sufficiently grateful to him for all the time and attention he had devoted to their affairs."

Sir Frederick J. West (Manchester), who seconded the motion, said everybody would be prepared to testify to the valuable services Lord Ritchie had rendered during his chairmanship and presidency of the Association. He had brought to bear upon the many difficult and complex problems which had come before them the great experience he had gained in the greatest port in this country and indeed in the world. No detail connected with any port in the country had been too small to call for his considered attention.

The motion was carried with acclamation, and the secretary, Mr. W. Ashley Cummins, was instructed to send a copy of it to Lord Ritchie.

The **Chairman,** in proposing the adoption of the report,* said they had to regret the death in October of Mr. George W. Service, a member of the Clyde Navigation Trust since 1905, who had represented the West Coast of Scotland on the Executive Committee continuously for the last 14 years. His profound knowledge of shipping matters was of great value to the Association and his loss was very much deplored. There had been no change in the number of members since the last annual meeting, the figure remaining at 56, which was, however, a high water mark. It was obvious there would be a number of important questions of common interest to dock and harbour authorities to be cleared up after the war, and the Association, which was the organisation recognised by the Government as qualified to act for the independent ports, would be busily engaged on those matters. It was therefore very important that the membership should include as many of the independent dock, harbour and conservancy authorities as possible, for the larger the membership the more influential would be the Association. He regretted there was still a small number of authorities who had not seen their way to join the Association, although they benefited by its activities. It was hoped they would reconsider the matter. Colonel Beazley went on to refer in detail to various matters dealt with in the annual report.

Alderman A. W. S. Burgess (chairman of the Port of Bristol Authority), who seconded the motion, said the Association had proved its usefulness through another year in extraordinarily difficult times and would continue to prove its usefulness in the years ahead.

The report was adopted, as also were the accounts, which were considered very satisfactory.

On the initiative of **Mr. William Cuthbert,** chairman of the Clyde Navigation Trust, seconded by **Mr. R. H. Jones,** Bristol Channel, Sir John H. Irvin, chairman of the Aberdeen Harbour Commission, was elected president of the Association.

Sir John Irvin returned thanks for his appointment and said he was surprised that there should be any port authority remaining outside the Association. He did not know any association that so quietly did such valuable work.

The following were elected vice-presidents on the proposition of **Mr. John A. Lindsay** (Leith), seconded by **Sir L. A. P. Warner** (general manager and secretary of the Mersey Docks and Harbour Board): Lord Ritchie of Dundee, Sir Richard D. Holt (Liverpool), Sir Ernest Herdman (Belfast), Sir Frederick J. West (Manchester), Sir Alfred Read (Ardrossan) and Sir Arthur Sutherland (Tyne). Mr. Clement Davies, K.C., M.P., was appointed Parliamentary chairman on the motion of **Sir Richard D. Holt,** seconded by **Mr. A. Johnson** (Portsmouth). The Executive Committee, on the proposition of Alderman J. S. Howarth (Preston), seconded by Mr. J. Wilson (Clyde Trust), was chosen as follows: Colonel J. G. B. Beazley (Liverpool), Alderman B. O. Davies (East Coast of England), Messrs. J. K. McKendrick (North-East Coast of England), R. T. Garrett (London District), Harry Parsons (South Coast of England), R. H. Jones (Bristol Channel), Leslie Roberts (Manchester Ship Canal), William A. Cuthbert (West Coast of Scotland), John A. Lindsay (East Coast of Scotland), and M. J. Watkins (Northern Ireland) and Major J. B. Hollwey (Eire).

*Published in the March issue of "The Dock and Harbour Authority."

Singapore Harbour Board

The Report of the Board for the year ended 30th June, 1940, gives the information that after providing for Debt Charges in the sum of $1,700,328,27, the Income and Expenditure Accounts shows a surplus of $2,171,777.57 as compared with a surplus of $1,292,556.76 last year.

The number and total net registered tonnage of vessels berthed at the wharves compared with the previous year was as follows:—

No. of Vessels	Net Registered Tonnage
3,121	9,793,293
3,386	8,367,219

The tonnage of cargo dealt with was 3,844,300, compared with 3,209,327 in 1939.

During the year 271 vessels (exclusive of the Board's own craft) were docked for repairs and painting, giving a total gross tonnage based on the tonnage in docks daily of 2,628,223 tons as compared with 2,558,681 tons for the preceding year.

The trade handled at the wharves during the year reached record proportions and was, in the aggregate, 3,844,300 tons being 20 per cent. more than that for the previous year. General cargo inward increased by 269,744 tons or 20 per cent., whilst general cargo outward increased by 270,364 tons or 23 per cent. Coal inward increased by 45,720 tons or 21 per cent. and coal outward increased by 16,590 tons or 7 per cent. Fuel oil inward increased by 17,312 tons or 14 per cent. and fuel oil outward increased by 15,243 tons or 13 per cent.

The average percentage of quayage occupied during during the year was 69 per cent. as compared with 59 per cent. for the previous year, and the average length of quayage occupied per vessel was 402-ft. as against 411-ft.

In view of the increasing volume of work it became necessary to re-open the Tanjong Pagar machine shops in April, 1940. The two dry docks in this section were occupied for 243 days throughout the year.

Retirement of Dock Official.

Mr. J. W. Grant, assistant traffic controller at the Southampton Docks for the past six years, has retired after nearly 45 years service with the Southern Railway Company.

Re-organisation of Port Labour

Scheme for Dock Labour in Merseyside, Manchester and Preston Areas

An Explanatory Memorandum issued by the Ministry of Transport gives details of the Government's arrangement for employing on a systematic basis all dock workers registered in the Mersey Port Area, including the Port of Preston.

The scheme came into operation on March 12th and some of the leading features, as set out below, have been extracted from the memorandum which is issued by H.M. Stationery Office at the price of 2d.

The scheme is specifically described as a war-time measure to secure the quicker turn-round of ships in port under which all dock workers at the ports in question shall be employed by the Minister of Transport on a guaranteed (weekly) basis, combined where possible with payment by results. In this way it is hoped to build up a regular and mobile labour force to handle rapidly and efficiently the heavy traffic which is passing through those ports.

To implement the Government plan, discussions have taken place between officers of the Ministries of Transport and of Labour and National Service, officers of the Transport and General Workers' Union, and representatives of the Employers' Association of the Port of Liverpool, and of the employers at the other ports concerned; the object is to utilise as far as possible the existing machinery.

The scheme will terminate at a convenient date after the conclusion of hostilities, and reasonable notice of termination will be given by the Minister, who will bear in mind the desirability of fixing a date which corresponds with the time when the Minister of Shipping relinquishes the requisition of British vessels.

Duties of "Approved Employers" and of the Men

"Approved Employers" are such master stevedores, master porters, etc., as may have registered with the Regional Port Director before Saturday, 8th March, 1941. Their obligations and the obligations of any man who wishes to enter the employment of the Minister, are contained in the documents of which specimens are annexed to the memorandum, as Appendices A and B respectively. Forms of application from persons, firms of companies who wish to become registered as approved employers may be obtained from the Regional Port Director; the conditions of service for the men (Appendix B) were circulated to them with their pay in respect of the week ending 7th March, 1941, and were assumed to be accepted unless notification to the contrary was given within the next four days.

In both documents the principal conditions and duties have been clearly set out, but provision is made for such modifications as experience or administrative convenience may show to be desirable. Notification of those modifications will normally be given to those concerned through their appropriate organisation.

Piece Rates

Committees at the ports composed of representatives of the Ministry of Transport and of the Transport and General Workers' Union and of approved employers, are now engaged in fixing piece rates for operations for which such rates are suitable. The general datum level is 10 per cent. below average pre-war output. These rates will come into operation as and when they are fixed. Existing piece rates will not be affected by this scheme.

Consultative Machinery

Although the Minister of Transport becomes the employer of labour, and the "approved employer" ceases to have direct interest in the matter, it is undesirable that the experience of the local Joint Committees for Dock Labour should be lost, and it has, therefore, been agreed that the Committees shall continue to function and assist the Regional Port Director.

Control of Stevedoring, etc., Operations

The Chief Traffic Manager (or similar officer) at each port is responsible to the Regional Port Director for supervising the stevedoring, master porterage, etc., operations of approved employers.

Labour Superintendent

The Labour Superintendent, with his local Port Labour Inspectors, and in consultation where necessary with the Chief Traffic Manager, is responsible to the Regional Port Director for the allocation and best utilisation of the available labour forces.

Registration

It is anticipated that the existing registration machinery will continue and arrangements made to provide that continuance of registration depends on membership of the Transport and General Workers' Union.

Regulation of Employment.

It is an essential part of the scheme that each man employed by the Minister shall present himself at a minimum of eleven turns each week and such other turns as he may be required to attend, and shall be prepared to undertake any work for which he is suitable which is required for the clearance of any ports in the area. The labour force cannot be fully utilised unless the Labour Superintendent is assured that it is properly mobilised.

Accordingly, it is provided in Clause 5 of the Terms and Conditions of Service (Appendix B) that any man who is absent from employment or fails to turn out when directed will lose his guarantee in respect of that week and will be entitled only to the amounts actually earned and he will be required to give an explanation; but in the case of certified sickness or other adequate reason for absence, the guarantee will be reduced by the number of turns the man is absent. The Port Labour Inspector will be responsible for deciding whether or not the guarantee has lapsed, or for what number of turns the guarantee is effective.

In addition, a Port Labour Inspector may in appropriate cases suspend a man from work under this scheme for a period not exceeding two weeks, without payment of the guarantee, and shall report any such suspension to the Labour Superintendent. The Labour Superintendent may, whether or not a man has been suspended by a Port Labour Inspector, suspend a man from work without the payment of the guarantee for a period not exceeding four weeks or may dismiss any man, provided that any man given notice of suspension or dismissal by the Port Labour Inspector or by the Labour Superintendent may within seven days of receiving notice, appeal to the Port Labour Joint Committee (or any sub-committee appointed for the purpose), whose decision, if unanimous, shall be final; if that decision is not unanimous the matter may be referred to the Regional Port Director whose decision shall be final. The Regional Port Director may also in his discretion and without any recommendation, suspend or dismiss a man. In any case in which action initiating or confirming suspension or dismissal is proposed to be taken by the Regional Port Director, the man concerned shall be entitled to appear in person, being accompanied if he wishes by an officer of the Transport and General Workers' Union, before the Regional Port Director.

Transport

The Minister accepts an obligation to ensure that reasonable transport facilities are available for the movement of men within the dock area.

Rates

The Regional Port Director may determine the charges to be levied for any services by approved employers for which labour has been provided under this scheme. He will appoint an Advisory Committee to assist him on this matter.

Shipowners and Traders

It is not intended to interfere with the freedom of choice between approved employers which shipowners and traders now exercise; the Regional Port Director, however, has certain powers under Appendix A.

Management Fund

It is intended that the scheme shall be self-supporting, and for this purpose a flat percentage will be added to the wages earned by any labour supplied to an approved employer under this scheme. The percentage will be the same for all ports in the area and will be fixed from time to time, probably at intervals of not less than three months, by the Regional Port Director. The initial percentage will be 25.

The wages earned will be paid to the Minister, plus the percentage which will be credited to the Management Fund—and from the Fund will be paid the expenses of management (including the employers' share of Health and Unemployment Insurance contributions) and the sums due to each man under the guarantee. The Fund will be underwritten by the Minister, but any deficiencies or surpluses will be carried over to the next period.

Administration

In Appendix C is given an outline of the arrangements proposed for the control and supply of Dock Labour at Liverpool (including Birkenhead). At those ports where there is a single employer (e.g., the Manchester Ship Canal Co.) the procedure will be simpler.

Dock Canteens

In connection with the foregoing scheme, an order has been issued by the Minister of Labour under which a dock authority after notice from an Inspector of Factories, expressly authorised, is required to provide and maintain:

"(1) A suitable canteen where hot meals can be purchased at reasonable times by persons employed in the dock or part thereof; and

(2) adequate and suitable facilities for washing, including the provision of soap and clean towels or other suitable means of cleaning or drying for the use of such persons as aforesaid."

The Order known as The Docks (Provision of Canteens) Order, 1941, can be obtained, price 1d., from H.M. Stationery Office.

Sliding Caissons for Dock Entrances

An Article for Students and Junior Engineers

By STANLEY C. BAILEY, Assoc.M.Inst.C.E., F.G.S.

There are three methods in general use for temporarily closing the entrances of docks and locks, viz., either by Sliding Caissons, Ship Caissons or by Gates.

Sliding or Rolling, also known as Box Caissons, are the most expensive, and their cost varies according to whether they have been towed from the works where they have been constructed to the dock, or have been built in sitû in the dock before the dams have been removed.

Their cost varies from £6 to £8 per sq. ft. of entrance area, of which from 25 to 35 per cent. represents the cover of the housing chamber or camber, and the operating machinery. In addition to the cost of the caisson, chamber cover and machinery, there is also the extra cost of construction of the caisson chamber, or recess into which the caisson is drawn.

latter and leakage of water into the dock. It is, therefore, essential that caissons should be stiffly constructed, so that the deflection under full water pressure shall be reduced to a minimum, and the lighter the caisson is made the greater will be the amount of ballast required to sink it.

When the water has been pumped out of a dry dock the caisson comes under the full water pressure up to H.W.S.T. on the outside, and it will deflect. This will disappear when the dock is full of water. Under a 15 ft. rise of tide the deflection of a well designed caisson with a dock emptied of water may amount to $\frac{1}{2}$ inch, so that the caisson is constantly "breathing" as the tide rises and falls, and the plates and rivets are correspondingly strained. The loss of weight due to rusting of the steelwork after years of service should also be taken into consideration, and the strains induced in the plating caused by one side being immersed in cold water at a temperature of about 50° F. while the dry dock side of the caisson may be exposed to a summer sun temperature of 120° F., or more in a tropical climate, causing contraction of the outside plating in contact with the water, and expansion of the plates on the dock side.

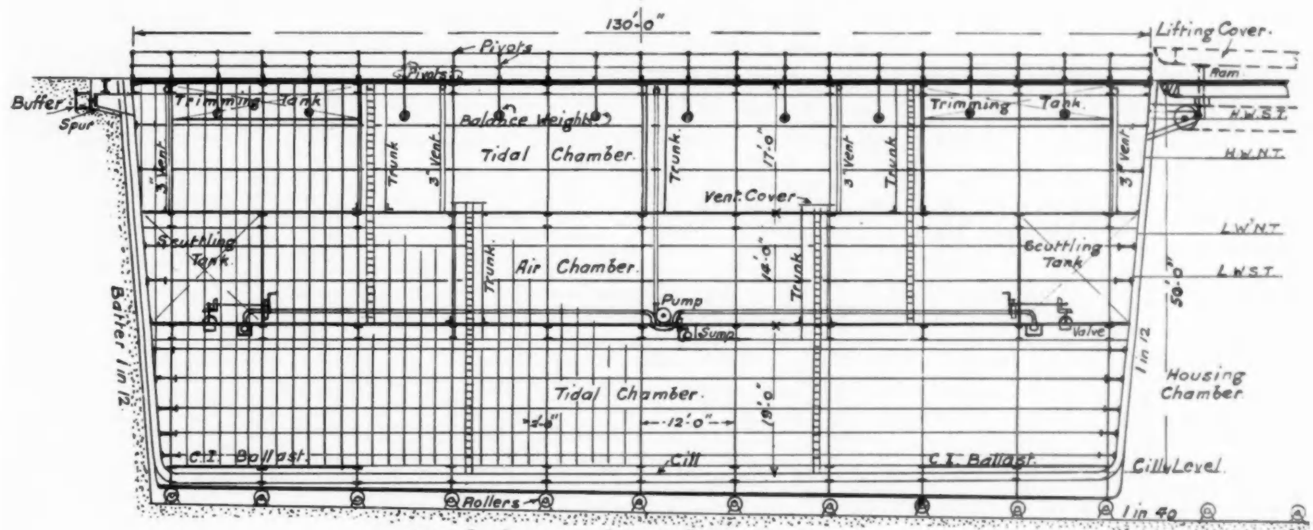


Fig. I. Longitudinal Section.

A sliding caisson is easy to operate, and the dock or lock entrance can be opened and closed rapidly, the caisson moving at a speed of from 20 to 25 ft. per minute. It makes a steady platform or bridge between each side of the dock for road and railway traffic, and should it become damaged, it can be repaired by divers, or removed easily and towed to another dry dock for the necessary repairs, its place being taken temporarily by a ship caisson, if available, or by a timber dam constructed in the outer stops or grooves provided in the entrance walls some distance outside the caisson, in which case the caisson can be repaired in the dock. If the sliding ways of the caisson are level, it can be reversed in the entrance, and each side can be thus scraped, tarred or painted on the dry dock side, but of course this cannot be done in cases where the caisson closes the entrance to a closed basin. The most suitable positions for sliding caissons are at the entrances to basins, locks, and dry docks from tidal harbours, or rivers, and especially where there is a large range of tide, as they are steadier than ship caissons when there are extraordinary high tides and rough water, the latter also, on account of their high freeboard when being moved in a strong wind, are difficult to manage in exposed positions, and may take 20 minutes to operate. If gates are used in such positions they require to be fitted with strutted frames on the dock side, and occasionally double gates are constructed for the same purpose.

Sliding caissons are actually portable dams, and should be designed accordingly, for in addition to the horizontal water pressure, they are subject to uplift. The width, or beam, given varies from $\frac{1}{4.5}$ to $\frac{1}{6.5}$ of the span; this is done to provide sufficient width for a road or railway, space for water and cast iron ballast, and to increase the buoyancy of the caisson when required to be floated into or out of the entrance.

Should the beam of a caisson be too narrow in proportion to the span, it will deflect laterally considerably, and strain the riveting, which will cause leakage at the joints. The railway on the deck will be put out of alignment, and there will be a tendency for the bearing portions of the stems against the entrance walls of the dock to open out, and instead of an equally distributed pressure on the bearing surfaces of the walls, there will be a concentrated pressure on the bearing timbers of the stems and the granite groins that may cause spalling of the

In sliding caissons there are usually three main decks and three chambers, viz., the upper deck used as a roadway, the upper tidal chamber deck (forming the roof of the air chamber) and the air chamber deck; below this to the cill level, the interior of the caisson is open to the tidal water through the lower braced girder which is partially decked to carry the cast iron ballast, and in a deep caisson additional horizontally braced girders may be introduced between the air chamber deck and the cill girder; this forms the lower tidal water chamber; both the upper and lower water chambers are also open to the sea at each end of the caisson.

The top deck has little lateral pressure, should it be just below the water level in caissons with falling road decks, but the lower decks and braced girders sustain the greatest water pressure in proportion to their depths below the water level.

The top and bottom decks of the air chamber must be strong enough also to sustain the vertical water pressures in the tidal chambers; this will be considerable, especially on the bottom deck of the air chamber, which will contain the scuttling tanks and also a certain amount of cast iron ballast.

The position of the top deck of the air chamber should be so arranged that should the caisson be required to be floated away from the entrance, this deck will have a freeboard of from 6 to 12 inches above the water level. The displacement of the immersed portion of the air chamber, timber, steelwork, and cast iron ballast, must be equal to the dead weight of the caisson for the particular floating out level. Sometimes sluices are provided in the caisson for filling the dock, but it is better to arrange for this by culverts and sluices in the side walls of the entrance.

At each end of the air chamber there are usually water ballast tanks formed by vertical cross bulkheads in the chamber, or independent rectangular or cylindrical tanks may be placed on each side of the centre line of the chamber. These are the

Sliding Caissons for Dock Entrances—continued

scuttling tanks for sinking the caisson in its groove, they are filled from the sea through sluice valves, and are emptied by pumping through electrically driven centrifugal pumps in the air chamber.

The scuttling tanks should be capable of holding sufficient water to keep the caisson sunk at extraordinary high tides which may be 2 ft. higher than H.W.S.T.

At each end of the caisson between the roadway deck and H.W.S.T. level are placed the water ballast trimming tanks, these are filled through a hose pipe from the shore water supply, and emptied by opening sluice valves.

These tanks are used to adjust the pressure on the sliding ways of the caisson and keep it steady, and also to prevent "kicking" of the caisson when being hauled into or out of the camber.

When caissons have falling decks there is no space available for trimming tanks; these must, therefore, be placed below the upper air chamber deck, being filled through sluices from the sea and emptied by pumps in the air chamber.

The road and railway deck is usually covered with 9 in. x 4 in. x 4 in. thick oak or creosoted hard wood blocks and elm horse treads, with provision for a railway line, if required, laid on longitudinal timber sleepers, the heads of the rails being flush with the road surface.

In some types of caissons the roadway deck is fixed and the handrail stanchions are pivoted at the deck level, the tube handrails are also pivoted. A proportion of the stanchions are continued down to the tidal chamber and terminate in balance weights, as illustrated by Figs. 1 and 2.

In these cases the chamber cover is hinged at the shore end, and raised at the outer end by a row of vertical hydraulic rams on each side spaced about 25 ft. apart longitudinally, the weight of the cover being about 70 lbs. per sq. ft. and for an entrance 130 ft. wide and caisson width of 26 ft., the cover would weigh about 125 tons.

The sliding ways are laid on an incline of 1 in 40 down to the housing chamber, and the camber cover, when raised, is on a similar incline. The outer end of the cover is fitted with a cast steel bull nose, and when the cover is raised, the shore ends of the caisson handrail stanchions strike against this and are depressed, as the caisson is drawn into the chamber.

Where hydraulic power is available, caissons have been constructed in which the roadway deck is supported on two rows of vertical hydraulic rams, about 3 ft. 6 in. apart, on each side of the centre line, the deck being carried by cantilevers outside the rams, as shown in Fig. 6.

The rams pass through the top deck of the caisson which is 6 to 7 ft. below the roadway deck, into the tidal chamber, the sides and ends of the caisson being carried up as bulwarks above high water level. In this type of caisson the sliding ways are level, and the camber cover is fixed.

Another method adopted is that on Kinniple's principle, in which the roadway is carried on vertical supports on each side of the caisson and about 6 ft. apart longitudinally. These supports are pivoted at the top deck of the caisson, which is about 6 ft. below the roadway deck, and they are also pivoted to this deck.

The supporting levers which also form the stanchions of the handrails when continued above the road deck, extend down into the upper tidal chamber and terminate in balance weights, as shown in Fig. 5.

When the caisson is drawn into the chamber having a fixed cover, the handrails and deck are depressed by striking against the bull nose steel casting at the outer end of the cover, and the stanchions bear against inverted steel channels under the cover.

The balance weights raise the road deck again when the caisson has been hauled across the entrance.

The keel of the caisson and the groove are level and there are steel girders and locking arrangements provided in the recess in the walls opposite the chamber to keep the caisson steady. A modification of Kinniple's method of lowering the roadway deck is to place the pivoted and counterweighted levers about 3 ft. off the centre line of the caisson on each side, while the handrail stanchions are pivoted to the road deck, as shown in Fig. 4, and the top deck of the caisson, and are not counterweighted, these support the outer edges of the deck. Vertical rollers are fitted at intervals of 12 to 15 ft. apart on the outer edge of the roadway deck on each side, these strike against the bull nose of the chamber cover and lower the deck. This method involves a longer recess in the upper portion of the walls opposite the camber, than is necessary with vertically falling decks, as the roadway when depressed extends several feet beyond the outer end of the caisson.

The weight of water displaced by the whole of the air chamber should not be less than the dead weight of the caisson, exclusive of cast iron or other ballast, additional buoyancy for floating out being obtained by the displacement of the steelwork, timber and cast iron ballast, and by emptying the water ballast tanks. Communication with the air chamber is obtained through vertical tubes or trunks, from 2 ft. 6 in. to 3 ft. dia. or square, with fixed ladders from the roadway deck, or other top deck of the caisson to the top deck of the chamber, the ladders being extended to the lower deck; these trunks are sufficiently large to enable a diver to enter the chamber should it be accidentally flooded, and are closed with watertight hinged covers.

Ventilation pipes, 3 in. in diameter, are also fixed to the upper deck of the chamber and to the scuttle tanks, and are carried up to the top deck of the caisson and bent over.

Additional trunks are fixed between the upper and lower decks of the air chamber to enable divers to reach the lower tidal chamber. These are provided with portable or hinged covers having ventilation holes on the top deck of the chamber so that water between the lower and upper tidal chambers will pass through these trunks.

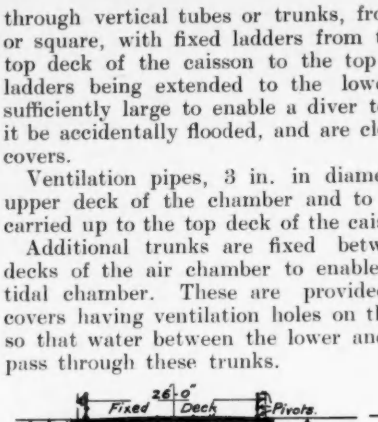


Fig. 2: Cross Section.

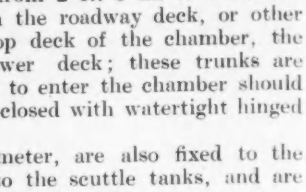


Fig. 4.

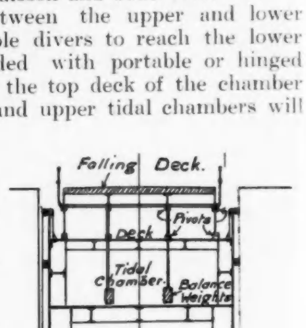


Fig. 5.

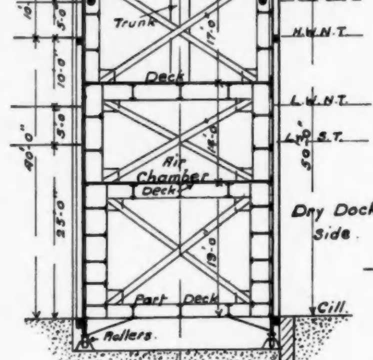


Fig. 3. End View.

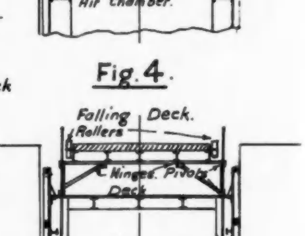


Fig. 6.

The top and bottom decks of the air chamber should be covered with from 1½ in. to 2 in. thickness of Seyssel asphalt and bitumen applied hot, and the accumulation of mud on the top deck of the air chamber, and on the girders and decking in the lower tidal chamber should be allowed for in the calculations.

The machinery used for operating sliding caissons, when hydraulic power is available, consists of a pair of horizontal engines with oscillating hydraulic cylinders, and suitable gearing engaging with pinions on the sprocket wheel shafts in a watertight pit at the head of the caisson chamber under the cover; and where electric power is used, the motors are of the enclosed type, the worms on which engage with the sprocket wheels through 3 to 1 reduction gearing.

At the machinery end of the chamber there is a vertical sprocket wheel, and also at the outer end on each side below the chamber cover, and endless steel linked chains pass round these wheels from end to end of the chamber.

At the upper part of the chamber end of the caisson, a V-shaped steel yoke is attached with a horizontal steel cross beam at the apex of the yoke, the outer ends of which are fixed to the endless chains, thus providing the motion to the caisson. Cantilever spurs at the shore end of the caisson on each side may be used in lieu of the yoke for the same purpose. In lieu of sprocket wheels and chains, sometimes grooved pulleys and steel wire ropes 1¼ in. in diameter are used, the beam on the yoke being clamped to the wire ropes.

In a recess in the masonry below coping level opposite the chamber, two spring buffers are fixed carrying a cross beam which engages with a projecting spur on the caisson and keeps it steady when across the entrance. The bull nose of the camber

Sliding Caissons for Dock Entrances—continued

or chamber cover also projects over the end of the caisson for the same purpose.

In order to get a sliding caisson into the entrance groove and to remove it when necessary for repairs and overhauling at H.W.N.T. the side walls of the entrance are given a batter of 1 in 12 on the faces, so that if the caisson is raised and the underside of the cill timbers is from 7 to 8 ft. above the cill level, it can be swung clear of the entrance and floated away, after the water ballast has been discharged.

To avoid raising the caisson so much, the difficulty can be got over by putting an outward splay in plan to the entrance walls, outside the caisson groove, but this involves longer wedges or struts to wedge the caisson up against the bearing faces of the masonry, this is necessary because the caisson will wobble, especially at low water.

A more satisfactory method is to splay the ends of the caisson in plan, the outside length being longer than the inside, but the length of the longest side should not exceed the diagonal length of the caisson, and in most cases a splay of 1 in 11.5 will be sufficient, the distance between the entrance walls being increased to suit the splay.

A caisson of this type would have a level keel and falling road deck and a fixed cover to the housing chamber, but it could not be reversed in the entrance for painting or repairs. It will only be necessary to raise it a few feet to clear the entrance groove in order to remove it.

The granite bearing faces on the entrance walls and cill for the caisson are fine axed, rubbed down with a carborundum block and sometimes polished, also the granite sliding ways in the caisson groove, if not fitted with rollers which will reduce the friction.

The runners under the caisson consist of flanged steel beams and, in addition to these, in some cases there is a flangeless roller under each end of the caisson on the centre line which travels on a cast iron roller path fixed to the floor of the groove, but this is liable to be obstructed by stones, etc.

Each roller is attached to a vertical shaft or spear which is connected to an hydraulic ram in the air chamber, by means of this arrangement the caisson can be slightly lifted off the sliding ways and will travel easier.

In other cases in which the groove is horizontal for a level caisson keel, instead of sliding ways, vertical flangeless steel rollers from 15 to 18 in. dia. and spaced about 8 to 12 ft. apart longitudinally, are carried on brackets fixed to the floor of the caisson groove, there being a row under each side of the caisson. The bearing rails under the caisson consist of flat bars of Delta metal rivetted to the bottom flanges of the steel beams that carry the cill clapping timbers.

The bearings of the rollers are usually of Delta metal or phosphor-bronze.

As regards the dead weights of sliding caissons exclusive of cast iron ballast, these vary between 3.07, 3.32, 3.34 and 3.38 cwts. per sq. ft. of entrance area to coping level, while ship caissons vary between 3 and 3.2 cwts. sq. ft., and gates from 2.5 to 3 cwts. sq. ft.

Steel burr concrete ballast weighs from 320 to 350 lbs. cub. ft. or 7 to 6.4 cub. ft. per ton. Pig iron ballast closely packed weighs 270 lbs. cub. ft., or 8.2 cub. ft. per ton to 284 lbs. cub. ft. equals 7.88 cub. ft. per ton.

Rectangular cast iron kentledge weighs 448 lbs. cub. ft. or 5 cub. ft. per ton, and when stacked it weighs 400 lbs. cub. ft. or 5.6 cub ft. per ton.

Concrete ballast at 140 lbs. per cub. ft. equals 16 cub. ft. per ton.

Asphalt weighs 156 lbs. cub. ft. or 13 lbs. per sq. ft. per inch thickness.

From 4 to 5 per cent. of the weight of the steelwork of the caisson should be allowed for rivet and bolt heads and nuts.

The weight of mud is about 54 lbs. cub. ft. or 4.5 lbs. sq. ft. per one inch thickness.

Each coat of red oxide of iron paint will increase the weight of the steelwork by 0.4 per cent., and red lead by 0.6 per cent. While tar and silica graphite will add 3 per cent. to the weight when painted on both sides.

The steelwork of the caisson in the tidal portions will displace 4.57 cub. ft. of water per ton of steel weighing 490 lbs. per cub. ft.

A caisson should be considered as a multiple box girder, subject to a lateral triangular load equal to the total head of water, the main bearings of the ends of the horizonal girders that form the decks or intermediate horizontal frames being the walls of the entrance, the pressures increasing from the surface of the water to the bottom.

Each deck is a girder in itself, the deck forming the web, and the side plating for a width equal to half the distance between the stringers above and below the deck being taken as effective flange area.

Should the decks be far apart the lateral loads on them may be reduced by introducing a braced horizontal girder midway between them, and as the decks and girders have free ends the B.M. at the centre will be $= \frac{W.L.}{8}$ and the shear $= \frac{W}{2}$ at ends, and zero at centre, and the stress on the flanges or side plating including the angles and steel channels will $= \frac{M}{D}$ where D = the width of the caisson to the C.G. of the flanges. The stress may be calculated by taking the moment of inertia (I) of the whole cross section of the girder in inch units, M being in inch tons, and Y which is half the width of the caisson also in inch units, then the stress $= \frac{M.y.}{I}$

At intervals of from 10 to 12 ft. in the length of the caisson vertical plated frames are constructed with a width of from 2 to 3 ft. against the plating on each side, these are braced together vertically across the width of the caisson.

Stringers or longitudinal and horizontal stiffening girders from 2 to 3 ft. wide are introduced at intervals of from 2 ft. at the lower portion of the caisson to 4 ft. in the upper portion, to which the side plating is attached, and the loads on them are transmitted to the vertical frames and from thence to the main decks and girders so that the vertical plated frames and the stringers are beams with fixed ends, and the B.M. at the centre $= \frac{W.L.}{24}$ and at the ends $= \frac{W.L.}{12}$, while the shear $= \frac{W}{2}$ at the ends and zero at the centre.

Between the main decks and the horizontal braced girders at intervals of about 2 ft. longitudinally, vertical angle steel ribs are fixed to support the skin plating, and as these ribs are fixed to the stringers and decks they will be calculated as for beams with fixed ends.

The decks which form about 33 per cent. of the weight of the caisson, will require to be supported by cross girders at intervals of 10 to 12 ft. longitudinally in connection with the vertical plated frames at the sides, and also with longitudinal beams to carry the road and railway on the upper deck and to sustain the vertical water on the decks at the top and bottom of the air chamber, also the weight of pumps, scuttling tanks, and iron ballast on the latter. A certain amount of decking will be required at the bottom of the caisson at each end for kentledge ballast.

The skin plating is usually in lengths of from 12 to 24 ft., and from 3 to 6 ft. wide, with lapped horizontal joints at the stringers and butt joints with outside cover plates at the ends.

The skin plating and decks of the air chamber will require to be caulked, the plates being slightly bevelled on the edges for this purpose, the skin plating of the tidal chambers will also require caulking.

As the skin plating forms about 18 per cent. of the dead weight of the caisson, the thickness of it which increases from the top of the caisson to the bottom in accordance with the water pressures and spacing of the stringers, is a matter of some importance.

The safe stresses allowed on it should not be higher than 6.5 tons per sq. in. in tension, because in addition to this there is also the additional stress due to its acting as the flanges of the main deck beams and stringers.

There are several formulæ for the thickness (T) of the plating in inches, where L is the vertical span of the plate in inches, between the stringers, and H is the depth of water in feet, they are as follows, viz., $T = 0{\cdot}00465\ L\sqrt{H}$.

$$T = \sqrt{\frac{L^2\ H}{44{\cdot}800}}\quad T = 0{\cdot}074\sqrt{H} \text{ and } T = \sqrt{\frac{0{\cdot}0001\ H.L^2}{S}}$$

where S is the safe stress in tons per sq. inch.

The first three formulæ allow for a safe stress of about 6.5 tons per sq. in., and a B.M. of about $\frac{W.L}{8}$, as any strip of plating between the supports is acting in the same way as the chains of a suspension bridge in which the stress $= \frac{W.L.}{8.V}$. V being the versed sine or deflection, and the deflection of the plating $= \frac{W.L^3}{384\ E.I.}$ where E = 30,000,000 lbs. and I is the moment of inertia in inch units, the plating having fixed ends.

The shearing stress on steel rivets in single shear should not exceed 5.5 tons per sq. in., and 9.5 tons sq. in. when in double shear, and on black bolts 4.5 tons in single, and 7.5 tons in double shear, as rivets will rust considerably in water.

The bearing stress on rivets should be limited to 10 tons per sq. in. of bearing area, and 8 tons per sq. in. for bolts.

The slipping friction of riveted joints amounts to 4 tons for $\frac{3}{4}$ in. rivets, and 5.5 tons for 1 in. rivets per rivet.

The pitch of rivets for watertight work should not exceed 3 times the diameter of the rivet, and the heads and snap ends should be pan-shaped or well rounded as they will be in direct tension on the dock side of the caisson when the former is empty of water.

The cill and stem bearing timbers are usually of greenheart planed to a smooth surface and bolted to the steel beams form-

Sliding Caissons for Dock Entrances—continued

ing the keel and stems on each side of the caisson. The bolts should be galvanised as they are very liable to rust away when in contact with wood; they should be at least $1\frac{1}{8}$ in. dia. for lengths up to 12 inches, and $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in. dia. for longer lengths, having a pitch of about 2 ft. and arranged zig-zag. All bolts should have a driving fit in the holes through the timber. The bolt heads and washers should be well countersunk into the timber and the holes plugged with hard wood.

As the keel and stem timbers will have to sustain very heavy pressures the bearing width should not be less than 12 to 15 inches, the joints being lapped, but they should be in single lengths when possible.

Demerara Greenheart (*Nectandia Rodiœi*) weighs from 68 to 75 lbs. per cub. ft. it has an average tensile strength of 3.93 tons per sq. in. = 565.92 tons per sq. ft. and an ultimate compressive strength of 5.814 tons per sq. in. = 837.2 tons per sq. ft. and $\frac{1}{10}$ of this may be taken as the safe load, and as it is not readily attacked by marine mollusca, it is not creosoted.

In the case of a caisson, as shown in Figs. 1, 2 and 3, for an entrance 130 ft. wide, with a batter of 1 in 12 for the side walls, and a depth of water of 45 ft. on the cill at H.W.S.T. the pressure on the stem timbers at cill level will be 1.28 tons per sq. ft. × 124 ft. = 158.72 tons, or 79.36 tons per sq. ft. on each side, so that a stem timber 12 in. wide will suffice.

Should the entrance walls be vertical and the ends of the caisson be splayed outwards in plan the pressure will be increased.

The centres of gravity and buoyancy of a caisson can only be accurately determined after it has been designed, and the procedure is as follows, viz.: Starting from a base line at or below the keel of the caisson, the weight of each item is calculated and multiplied by the distance of its C.G. from the base line, and when the sum of all weights (W) and moments (M) are taken, then the vertical distance (x) of the C.G. from the base line will be $x = \frac{M}{W}$.

In tabular form the items should be arranged as below:—

Item.	Weight of item in lbs.	Leverage from base line to C.G. of item in feet.	Moments in foot lbs.

A similar table should be prepared for the buoyancy of the caisson, taking the weight of sea water at 64 lbs. per cub. ft. = 35 cub. ft. per ton.

Before the final drawings are prepared preliminary designs are made to fix the levels of the top and bottom decks of the air chamber and to estimate the weights and buoyancies.

With regard to the stability of caissons when being floated into or out of the entrance, in order to keep the C.G. below the C.B. a considerable amount of cast iron ballast or kentledge will be required on the partial deck at the keel level, to give the necessary stability because unlike steamships there is not a sufficient preponderance of heavy loads such as engines and boilers at the bottom.

Although a certain amount of equilibrium may exist with the C.G. slightly above the C.B. the stability is always increased by lowering the C.G. below the C.B. for then the lever arm of the couple which tends to right the caisson is increased when it is careened at an angle.

During sinking operations the C.G. should not be less than 8 inches below the C.B.

It cannot be determined from the relative positions of the C.G. and C.B. alone whether the caisson will be stable or not, but only from the metacentric height, or the position of the metacentre (M.C.) with regard to the C.G. Should the M.C. be above the C.G. the caisson will be stable, but if it falls below, it will be unstable and will not right itself.

The position of the metacentre is found as follows: When the caisson is careened at an angle (Θ) with the sea level as shown in Fig. 7, there will be a new centre of buoyancy, the water displaced being still equal to the weight of the caisson, and if a vertical line is drawn through the new C.B. until it cuts the inclined axis of the caisson drawn through the C.G. the intersection of these lines will be the metacentre. During a strong wind and rough water it is advisable to keep the M.C. near the C.G. otherwise the caisson will be too lively, the C.G. should not be less than from 2 ft. to 2 ft. 6 in. below the M.C. in caissons, but in ships it ranges from 1 to 4 ft. according to the type of ship.

The righting lever (x) is the horizontal distance from the new C.B. to a vertical line passing through the C.G. of the caisson and the righting moment will be = Wx.

The pendulum distance (P) between the C.B. and C.G. should be about 18 inches for sliding, and 13 inches for ship caissons. If R = the metacentric radius, which is the vertical distance of the M.C. to the C.B. and P = the pendulum distance between the C.G. and C.B. the angle of inclination (Θ) at which the caisson will find its stability = $\text{Tan}\ \Theta = \sqrt{2\frac{P-R}{R}}$

If Q = the wind pressure on the side of the caisson, and h = half the vertical height (H) on which the wind acts, then the moment of the wind will be Q.h. and the moment of resistance of the caisson will be Wx.

With reference to Fig. 7 should it be required to careen the caisson at an angle (Θ) by moving a weight from the centre of the air chamber to the side as at P the C.G. of the caisson at G will move horizontally from G a certain distance (a) $= \frac{Px1}{W+P}$ and vertically from G a distance (b). $= \frac{Py1}{W+P}$ forming a new centre of gravity at G.1 and if a line is drawn through this point parallel to the inclined axis of the caisson until it cuts the vertical line through the C.B. of the inclined caisson the metacentre will move from m to M.

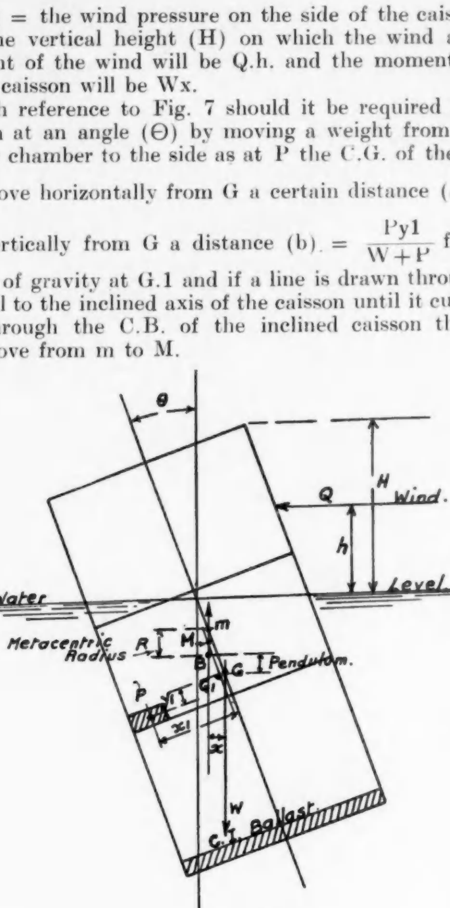


Fig. 7.

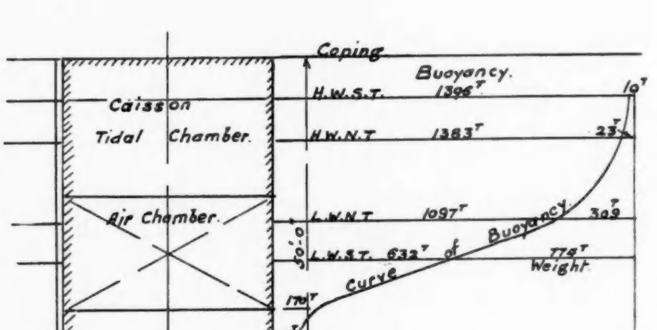


Fig. 8.

When it is required to move the caisson into or out of the housing chamber or camber, the water should of course be level on each side of the caisson so that there is no lateral pressure, and the resistances to be overcome will be the weight of the caisson on the sliding ways, including all ballast, the friction of the slides or rollers and of the keel and stem timbers against the entrance wall and that of the housing chamber on the dock side, also the resistance of the water against the end plating of the air chamber and the partial plating at each end of the tidal chambers, there will also be the friction of a falling road deck against the underside of the housing chamber cover.

When the level of the water on each side of the caisson is at H.W.S.T. the maximum amount of water ballast will be in the scuttling and trimming tanks to keep it sunk, plus an additional, say, 10 tons to keep it steady, this will be the weight on the sliding ways at H.W.S.T.

At H.W.N.T. there will be an additional load on the sliding ways which will depend upon the difference between the levels of H.W.S.T. and H.W.N.T. so that the calculations for the power of the machinery should be based on operating the caisson at H.W.N.T.

If the weight on the ways at this tide is 23 tons in the case of a caisson for an entrance 130 ft. wide and 50 ft. deep from coping

Sliding Caissons for Dock Entrances—continued

level to cill, and a depth of 40 ft. at H.W.N.T., the calculations for the motive power required will be as follows, viz.:—

The coefficients of friction for metal sliding on wet stone = 0.3, for timber sliding on stone = 0.4, for steel sliding on cast iron = 0.2 and for rollers it is very small.

As the caisson will not be bearing tightly against the walls when being moved, to arrive at the amount of wall friction, it is assumed that a strong wind at a pressure of 20 lbs. per sq. ft. is blowing against the outer side of the caisson having an exposed area of 132 ft. × 10 ft. = 1,320 sq. ft., this is equivalent to 11.78 or, say, 12 tons pressure.

The plating area at the ends of the caisson where immersed in water = 1,350 sq. ft. and the water pressure in lbs. per sq. ft. will be = $P = 1.184\ V^2$ where V is the velocity in ft. per second, and if the caisson travels at 25 ft. per minute = 0.416 ft. per sec., then $P = 1.184 \times 0.416^2 = 0.204$ lbs. per sq. ft. and $1{,}350 \times 0.204 = 275.4$ lbs. = 0.122 tons.

The friction due to the counterbalanced falling deck and handrails striking against the chamber cover and rubbing against the underside may amount to so much as 18 tons for a large caisson which multiplied by 0.2 = 3.6 tons, therefore the H.P. of the machinery required will be as follows:—

	Tons.
Weight of caisson on sliding ways =	23.000
Friction of water at ends = 1,350 sq. ft. × 0.204 =	0.122
Friction of sliding ways, 23 tons × 0.3 =	6.900
Friction of timber on walls, 12 tons × 0.4 =	4.800
Friction of falling deck on cover, 18 tons × 0.2 =	3.600
	38.423 say 39 tons.

$$\therefore \text{H.P.} = \frac{\text{W.V.}}{33{,}000} = \frac{39 \times 2240 \times 25}{33{,}000} = 66.18$$

Add machinery friction 25% = 16.54

82.72 H.P. say 83 H.P.

and $83 \times 0.746 = 61.918$, say 62 Kilowatts.

The curve of buoyancy of the caisson illustrated when sunk in the entrance at different tide levels is shown by Fig. 8, but when the dock is empty of water the buoyancy is slightly less, and at H.W.S.T. the weight on the sliding ways will be nil, due to the lateral water pressure of the caisson on the walls and the friction.

For instance, in the case of the caisson shown in the sketches the total lateral pressure at H.W.S.T. will be 3,805 tons, and the weight of the caisson and all ballast will amount to 1,406 tons, the caisson weighing 1,050 tons, the cast iron ballast 205 tons, and the water ballast 151 tons.

Goods Permits for Mersey Ports

Details of Regulations

The system of permits at Merseyside ports for export goods outlined in the March issue, the inauguration of which was postponed temporarily, has now come into operation in conformity with the following detailed regulations issued by the Liverpool Port Emergency Committee.

The Committee state that they desire to make clear that the method of applying the new plan will be kept as elastic as possible so as to cause the minimum disturbance to existing practice. They are prepared to agree to shipping companies making such arrangements for detailed working of the regulations as will meet their several requirements provided the object for which the regulations are being introduced is achieved. Modifications will be made in the regulations if necessary. The permit regulations are as follows:—

1. The regulations have come into operation as from March 12th, 1941, and from that date goods for export, except coastwise and Irish traffic, will only be accepted by permit.
2. The permit regulations will apply to cargo delivered to the berth by rail, or road (including all Government cargo for shipment in commercial vessels); a permit must be obtained in respect of transhipment cargo carted from coastwise vessel to foreign-going exporting vessel.
3. It is not essential that a separate document be used as the form of permit. The permit can be embodied in existing shipping notes. The form the permit shall take is left to the individual shipping companies, but the permit must state a date, and, if necessary or desirable in the case of road transport, a time by which goods shall be delivered at the docks. The date given should be the date on which the goods are wanted on the quay to fit in with the loading programme. The date must be decided upon by the Liverpool or Birkenhead office of the shipping company.
4. The general procedure will be as follows:—
   (a) Shipping companies will advise their customers of prospective sailings as usual.
   (b) The shippers will inform the shipping company, either direct or through their forwarding agents, of their intention to ship goods, giving the usual particulars, as to class of cargo, weight, measurements, etc.
   (c) The shipping company will advise the forwarding agent or the shippers or their suppliers, that the goods can be received and arrange for the issue of a permit.
   (d) Road.—For goods sent by road the permit must be sent with the goods and produced to the wharfinger at the dock.
   In the event of a consignment being conveyed in a number of road vehicles on the same day it will only be necessary for one permit to be issued. This permit should be produced to the wharfinger at the dock by the first vehicle. Drivers of other vehicles conveying goods forming part of the same consignment from the same supplier must be provided with a shipper's or supplier's "part lot" note. Goods coming forward without permit will not be accepted.
   (e) Rail.—For goods sent by rail the sender will, on handing in his goods at the forwarding station, endorse the railway consignment note that he holds a permit for such goods, thereafter conforming with instructions which will have been issued by the shipping companies.
   (f) In order to ensure the acceptance on the quay of goods requiring Customs pre-entry, the necessary documents must be available at the dock before the arrival of the goods, and shippers and their agents must take effective steps to ensure compliance (e.g., by seeing that Licences, Forms C.D.3, etc., where required, are available at the port in sufficient time).
5. In the case of firms loading at an Unappropriated Berth, the Port Authority are being asked to co-operate to ensure that as long notice as possible is given of the berth allotted in order that forwarding arrangements can be completed.
6. In the case of cargo carted from railway station to quay by forwarding agents, the Committee would urge that forwarding agents exercise control over the delivery of this cargo and ensure that the goods can, in fact, be accepted promptly at the quay, thus obviating undue delay to road transport.
7. In the case of shippers forwarding large quantities of cargo to a number of shipping companies simultaneously, if, when permits are granted, it is found that the quantity of cargo to be forwarded on any day is beyond the capacity of the sender, it is up to the shipper to establish contact with the shipping companies concerned and arrange for an adjustment in the distribution of tonnage to be forwarded on individual days.

Obituary

Much regret is felt on Tyneside at the death, at the age of 68, of **Mr. Albert Blacklock,** who, until his retirement in June last year, was Secretary and General Manager of the River Tyne Improvement Commission, with which body he had served over fifty years. He commenced as a junior clerk in 1888 at the age of 15, became principal clerk in 1905, assistant secretary in July, 1922, and secretary in October of the same year. In November, 1937, he took over the general managership in addition to the secretarial duties. His knowledge of Tyneside affairs was profound and he played an important part in port developments. In 1939, in recognition of his services in promoting trade between the Tyne and Norway, King Haakon conferred on him the Order of Chevalier, First Class, of the Royal Norwegian Order of St. Olav.

The death is announced of **Sir Sidney Richard White Humphries, J.P.,** until his retirement two years ago, a member of the Bristol Docks Committee, the interests of which he had served for a period of 20 years by active propaganda abroad and by the notable part he took in promoting the dock extension scheme at Avonmouth.

The death at the age of 74 is announced of **Captain Owen Jones, C.B.E., R.D., R.N.R.,** a former member of the Port of London Authority, on which body from 1930 to 1936 he was the official representative of the Corporation of Trinity House. Capt. Jones was an Elder Brother of Trinity House.

On the eve of going to press news has been received of the death on the 22nd March at the age of 72 of **Sir Richard Durning Holt, Bart.,** Chairman of the Mersey Docks and Harbour Board since May, 1927. A biographical notice of Sir Richard was given in the issue of February, this year.

Pile Protection from Marine Organisms

Description of an American Pile Shield*

By JACK UPTON, Cambridge, Mass., U.S.A.

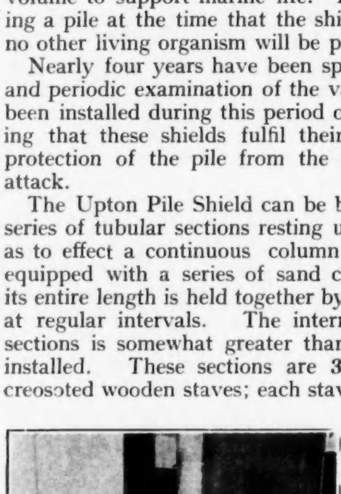
The marine borer attack that has ravaged pile-borne structures along the entire Atlantic seaboard of this country has lasted for a decade. In this interval it has been necessary to spend millions of dollars to rebuild some of the most important and vital wharf structures as a result of damage caused by their activity. The cumulative effect of this continuous attack is such that it is only a question of a short period of time before the majority of wharves and piers supported on untreated or unprotected piling will be found to be unsafe for public use because of the destruction of that portion of the pile most subject to attack, that is, from the mud line to Mean Low Water. Anticipating the need for an adequate device to protect this piling against further ravages of the marine borer, a Pile Shield has been developed.

Completed Base of Shield Showing Method of Sealing Bottom with Sand Checks.

Innumerable examinations which have been made under many wharves during the process of reconstruction indicate that that portion of the pile buried below the mud line is completely free from marine borer attack. The idea of the shield being that if the mud line be elevated above the high water line, or high point of attack, the marine borers cannot, consequently destroy the pile. The biological reason for the protection offered by the Upton File Shield being that the presence of sand eliminates the possibility of free and dissolved oxygen to be present in sufficient volume to support marine life. Hence, any marine borer infesting a pile at the time that the shield is installed is destroyed and no other living organism will be present on the pile itself.

Nearly four years have been spent in perfecting this pile shield and periodic examination of the various test pile shields that have been installed during this period of time have been made indicating that these shields fulfil their proper function, namely, the protection of the pile from the mud line to the high point of attack.

The Upton Pile Shield can be best described as consisting of a series of tubular sections resting upon one another in such a way as to effect a continuous column, the lower end of which is equipped with a series of sand checks. The shield, throughout its entire length is held together by means of metal bands or hoops at regular intervals. The internal diameter of the pile shield sections is somewhat greater than the pile about which they are installed. These sections are 3-ft. long and are made up of creosoted wooden staves; each stave interlocking with the one next adjacent and each section being held together by means of so-called guide staves covering the horizontal joints.



Method of Assembling Section. After Installing Staves, they are Bound with Monel Wire and Clamps.

The sand checks are installed in the base member of the shield in such a way as to always be in intimate contact with the surface of the pile at or near the mud line. These sand checks, as their name implies, prevent the flow of sand out through the bottom of the pile shield. The purpose of the shield is to retain a column of sand about the submerged portion of a pile thereby preventing the marine borer from having access to the pile and consequently preventing its further destruction.

The mechanical steps of erecting the pile shield are extremely simple in that we have found through past experience that the shields can be applied above the water line under the wharves by workmen supported on floats placed on either side of a bent of piles. The cost of the application of the shield is relatively low as compared to that of replacing badly damaged piles with new creosoted or otherwise protected piles.

*Reproduced from September, 1940, issue of "World Ports."

The important factors influencing the design and the construction of the Upton Pile Shield include these eight considerations:—

1.—Initial Investment and Maintenance Cost: The Upton Pile Shield installed costs about 50 per cent. of the cost of replacing a damaged pile with a new treated pile. With an expected life of 15 years, little in the way of further repairs will be needed.

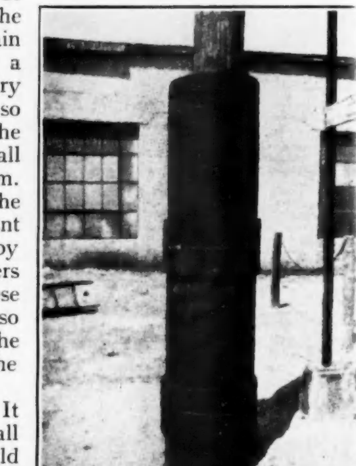
2.—Ease of Assembly and Installation: The simple design of the component parts of the Pile Shield make it possible to use any labour in the erection of the Shield. The Shield is designed to be assembled by men working on floats or staging under the wharf structure.

3.—Longevity: The use of creosoted wooden staves has been selected to give an expected longevity of 15 years. The history of creosoted piles and other timbers shows that this life expectation is reasonable.

4.—Adaptability to Movement of the Harbour Bottom: In the event that movement takes place on the harbour bottom on which the pile shield rests, complete protection is provided for. Thus the lowering of the existing mud line is protected against attack by the settlement of the shield down the pile to a new position of repose.

5.—Protection Against Ice Damage: In northern waters a slight amount of ice damage to the upper portion of the pile shield takes place. A badly damaged upper section can be removed and replaced with a new member. The shields, provided they run up on the pile high enough, afford considerable protection to the pile against ice.

6.—Effective Closure of the Undermost Unit of the Shield: In order to maintain the artificial mud line at a constant level, it is necessary that provision is made so that the sand filling the shields protecting a pile shall not run out at the bottom. Thus effective closure of the bottom is vitally important and this is accomplished by means of the bottom members or sand checks. These closure means are designed so that the bottom section of the shield is centered about the pile as well.



Complete Assembly of Pile Shield Base and Two Sections.

7.—Centering the Pile: It is important that, at all times, the pile itself should be kept as nearly centered as possible within the Shield so that the formation of large voids in the sand fill can be prevented. This is accomplished through the use of the finger stave. This stave is designed to rest against the side of the pile and keep the side of the shield away from the pile, thus providing space through which the sand fill can flow freely.

8.—Flexibility: Since most wharves are subject to lateral movement from various causes, it is necessary that there be articulation in the protective device. The Pile Shield, constructed in sections, amply provides for this articulation through the flexibility of the lateral joints between these sections.

The first pile shield installation was made, experimentally, in April, 1937, in Boston, under one of the wharves of the Mystic Terminal Co. The second installation was made under the wharf of the New England Coal and Coke Co., at Beverly, Mass., in April, 1938. The first commercial installation was made under the wharf of the Edgartown Yacht Club, Edgartown, Mass., in the autumn of 1938. There are, at the present time, nine pile shields installed at various sites in New York Harbour, for experimental purposes, to determine the feasibility of the shield in conditions that are found to exist in that water. These shields were installed in June, 1939.

Opposition to St. Lawrence Ship Channel Scheme.

At the annual general meeting of the Shipping Federation of Canada held at Montreal in February, strong antipathy was expressed by the chairman, Mr. M. McD. Duff, to the proposal for a deep navigable waterway through the St. Lawrence River to the Great Lakes. He said: "The Federation over a long period of years has viewed with much concern the agitation in certain quarters for the construction of this waterway. Many years of propaganda favouring its construction as a navigational project failed to impress the people of Canada, but it would appear that the navigational aspect is no longer considered of prime importance and that other aspects of the scheme have come prominently to the fore. Viewed from either a navigational or a power standpoint, there does not appear justification, from a Canadian point of view, for embarking on this ambitious and expensive project, especially at a time when our direct war effort requires heavy calls on the Canadian taxpayer, with promise of further calls."

The Efficiency of American Ports

War-time Problems

**Address by* BRIGADIER-GENERAL THOMAS M. ROBINS, *Assistant to the Chief of Engineers of the United States Army and Chairman of the Rivers and Harbours Board.*

The peace-time value of our ports was indicated by the opinion, freely expressed, of our national leaders that the well-being of our country is very dependent upon world trade. It goes without saying that no worth-while world trade can exist without adequate ports.

In the matter of national defence, there are certain necessary auxiliary measures which are only slightly less urgent than the provision of an adequate Army and Navy. Improvement and maintenance of auxiliaries for navigation is one of the most important of these auxiliary measures. After war is declared it is too late to get ready. We must become so thoroughly prepared that any aggressor nation that feels they have a right to own the earth must be convinced of our determination and our ability to maintain the independence of the free nations of the Western Hemisphere. The important role which our ports and navigation facilities play in the every-day life of our people is not understood or well understood by the majority. Although our country is self-sufficient in many ways, still there are many necessities and comforts of every-day life that must be brought to us from abroad in ships.

Perhaps of even greater importance to the every-day life of the nation is the transfers of goods by water between our own widely-separated coasts and between the Ports of the Great Lakes. Without this economical system of water transportation which we have built up our standards of living would be much lower and the cost of living would certainly be much higher.

The average citizen, when he visualises a port or stands on the deck of a ship entering a harbour is prone to think that that harbour or that port is a natural gift to mankind; it was just presented to us. That point of view is understandable, but, of course, it is far from true.

Port Improvements often not Visible

Many of the essential improvements that have been made at all of our ports are under water and can't be seen; they are hidden. The huge developments which have been brought into being by the Port Authorities have come about so gradually and with so little fanfare and blowing of trumpets that people just take these things for granted.

In the natural state, our entire coastline along the Atlantic and Pacific Oceans and the Gulf Coast had very few deep harbours and along the American shores of the Great Lakes there were practically no natural harbours of any commercial importance, and for over a century the federal government and our Port Authorities, as represented by you people here to-day, have been engaged in transforming these shallow bays and the rivers of our country into commodious landings and havens for world commerce. After working for these hundreds of years or so, we now have facilities that are unsurpassed by any other nation in the world, I think. This achievement is the result of far-seeing vision and sound engineering and steadfastness in execution. It is an achievement of which every citizen should be conscious and may well be proud.

Speaking for the Corps of Engineers I want to say that we deem it a great pleasure and privilege to have been designated by Congress from the beginning to carry out the work of river and harbour improvement, and also we deem it a great privilege to have worked side by side with the Port Authorities in this great undertaking. The Corps of Engineers certainly appreciates the unfailing co-operation and assistance of the Port Authorities of the country.

The millions of dollars which have been expended over a long period by the federal government on seacoast harbours and channels becomes insignificant when compared to the value of our water-borne commerce which is measured in billions of dollars each year. The federal expenditures are likewise dwarfed by the non-federal expenditures made in connection with the complex facilities and activities of the modern ports. A port nowadays involves the construction of wharves, piers, dry docks, rail connections, highways, bridges, tunnels, ferries, and lighters. All these things are a part of the mechanism of water transportation to-day.

Other requirements have to be met, as you well know, having to do with an endless list of minor facilities. The investments involved in port development are indeed very great but it should always be borne in mind that these investments make possible the free and continuous flow of goods in and out which sustain the life, health and happiness of the inhabitants of the hinterland, many of whom have never even seen a port or even thought about it. It may truly be said that the tremendous task of port development that has been accomplished by our Port Authorities benefits almost every phase of our national life.

Ports in Time of War

Important as ports and navigation facilities are in time of peace, they became of even greater importance in time of war. One needs only to read the newspapers to be convinced that well-designed and equipped ports and connecting channels are essential to waging a successful war. Even the daily bread of some of the warring nations is now dependent upon adequately equipped ports, adequately defended. Fortunately, we would not, in time of war, be dependent upon our ports for life sustaining food and fortunately, our ports have been developed sufficiently and with sufficient flexibility after the American fashion to handle overloads of traffic on short notice, an inevitable demand of war. Nevertheless, it behoves us now to take stock of our port facilities from the standpoint of preparedness for war and to see to it that no essential facility is lacking.

It has often been said that the war is fought with the Navy that exists at the beginning of hostilities because there is no time to build a Navy after you get into war. This axiom applies also with equal force to port facilities. We must plan and build in time of peace the ports and connecting channels that will be needed in war and we must make full preparation to maintain and defend these navigation facilities.

During the last war our ports on the Atlantic Seaboard—which were called upon to bear the brunt of the effort—were severely tested and not found wanting. Since that time, almost all our ports have been expanded and improved. We can go to war to-morrow with more confidence in the adequacy of our ports than ever before, but we must not lose sight of the changes in transportation requirements brought about by the mechanization of our armed forces. If I am not mistaken, this factor is one of the most important to consider to-day. Have we at our strategic ports, the embarking facilities, the open storage and the gear to load promptly on the ships, where our troops embark for the theatre of operation, the tanks and the other heavy mechanical equipment which they will have to have and which will have to go along with them?

Another consideration has to do with provisions for handling explosives. Here we got at the proper ports the proper facilities to handle the explosives without endangering the lives of the people who live in the neighbourhood and with the maximum insurance against sabotage and other unfortunate happenings in the way of explosives?

Having seen to it that the facilities at our strategic ports are adequate for war, provisions must be made for the proper co-ordination and use of these facitilies during hostilities. There must be no confusion, no congestion, no square-pegs, nonchalantly rolling into the port to be fitted in round holes. No port should be called upon to handle material and supplies that it is not equipped to handle, and no port in time of war should be turned into a storage depot any more than a transit shed in time of peace should be turned into a warehouse.

We are to be congratulated on having already set up in time of peace the instrumentalities that can be depended upon by the military authorities to insure the proper co-ordination and use of our ports in time of war. I refer to the American Association of Port Authorities, the American Trucking Association, and other similar organisations having to do with transportation. These agencies, in addition to co-operating in the war effort, can readily furnish for the military organisation the experts that are needed to take the helm in regulating traffic.

The transition from a peace to a war basis in the handling of our ports will be very easy because we have these organisations going in time of peace and because they are so efficient. No matter how well planned and well regulated the flow of traffic won't flow unless the mechanical facilities that are necessary for handing it are manned efficiently and continuously. Provisions must be made to prevent the interruption or the interference with the flow of traffic on account of labour disputes or anything of that kind. The working man should, through the big labour unions, be represented in the war organisation of the ports and if he is well and truly represented, I think the nation can depend upon his patriotism and upon his willingness to see the emergency through. In any event, though, consideration should be given to organising labour battalions to take over the operation of our most important ports of embarkation if need be.

In conclusion, let me say that it is our duty to see that national leaders and the public at large do not permit the importance of our ports and navigation facilities, both in peace and in war, to be overlooked in the drive for military preparedness. The actual defence of the coast and of the shipping routes must necessarily be left to the military authorities. In the present emergency, the Corps of Engineers is well prepared to perform its military duties, and in addition to that, take care and carry out any essential work for river and harbour improvement or for flood control that may be needed.

The Corps of Engineers, and you gentlemen of the Port Authorities, throughout the country, have co-operated fully in time of peace in accomplishing our respective missions in the development of shipping facilities, and there is no doubt in my mind but what we can, in the same co-operative manner, prepare ourselves for any emergency, come what may.

***Delivered at the 29th Annual Convention of the American Association of Port Authorities, 1940.**

Port Facilities and Dispersal of Industry

A Paper with the above title was read by **Mr. Andrew C. O'Dell** before the Royal Geographical Society on February 10th. We are indebted to the report in *Lloyd's List* for the following summary of the Paper:—

The last few years, said Mr. O'Dell, had seen a growing tendency to regard dispersal of industry as a panacea for the obvious ills consequent upon industrial concentration, and many town-planners appeared to regard it as a simple matter, to select new sites and clear the old and more congested without attention to geographically relevant factors such as port facilities. Ports were controlled by the permanent and inescapable physical geography of the land and sea conditions. In the past there were 140 small harbours girdling the mainland of Scotland, such as Wigtown, Eyemouth and Helmsdale, allowing the raw materials of local industries to pass in and the products to pass out. To-day many of those were but decaying quays—either because of sea conditions or because of the changing economy of the land.

The basic function of a port was to facilitate the transfer of freight and passengers between the water carriers and the hinterland. Once established port facilities existed that function was transcended. Factories crowded round the port in order to reduce transport charges, and the development of port and industries reacted one upon the other. The hinterland was divisible into three parts: (1) the local hinterland which was almost non-competitive within which the goods could be immediately conveyed by lorry; (2) the towns in the back country which should be cheaply served by the port owing to proximity; and (3) the competitive hinterland, where shippers had almost equal choice of several gateways.

It was impossible from available data to draw rigid lines dividing an industrial region such as the Central Lowlands of Scotland into those three-fold port zones. Glasgow, for example, dominated the whole of the country for certain commodities, while the Lanarkshire coal pits, owing to the close network of railways, exported coal through a variety of ports although they lay within the close hinterland of Glasgow.

Many ports for the sake of revenue attempted to force too much traffic through the bottleneck of the trans-shipment quays, and that ultimately spelt inefficiency. A marine terminal was essentially a national and not a local or private utility, and should be organised in public interests. The railway-owned ports were in the most advantageous position for attracting traffic, since they were best able, through their commercial agents, to press their claim.

Points of Appeal

The two main effective points of appeal to the shipper were low dues and rapid dispatch facilities. Dispatch facilities depended not only on port equipment but also on the frequency of sailings, in which major ports had so great an advantage. The efficiency of a port was nevertheless not measured merely by its size, but by performance. The equipment of a port must progressively improve to maintain the trade handled; the layout as well as the appliances being understood in the term equipment. The size of ships had increased in a spectacular manner during the last hundred years, and those larger capacity ships meant that there must be more facilities for cargo handling along each unit of quay. The great liner needed a quick turn-round to reduce the tremendous daily overhead costs, and that had meant that ports which catered for them had had to provide improved appliances for cargo handling, bunkering and water, as well as an adequate dock labour pool. Those increases had also demanded progressive improvements in depths and other clearances, and ports unable to stay the pace had languished from self-strangulation, while even such trade as might have continued in smaller vessels had too often passed to the better provided ports.

The development of a port was naturally dependent on the industrialisation of the hinterland. Packed into the Central Lowlands was a mass of the population, associated with the greatest degree of industrialisation, and it was significant that there were found all the great ports, save those which specialised in fishing. Certain industries required bulky imports of raw materials, and in the immediate vicinity of the waterfront were found various consuming factories. To divorce the factories from that proximity would be to place a severe handicap on the industries in meeting the competition of foreign producers.

Future port development must be controlled with an eye to the needs of future generations. Too often in the past the work of one generation had had to be destroyed, instead of being developed, to meet the needs of the case. Offensive industries such as oil, garbage disposal, gas and chemical works, ought to be placed well to the leeward of the town. The plans for the growth of the port should envisage the need for road as well as rail transport, for a harbour for pleasure craft, for accessible dormitories for workers, and for a well-planned approach from the sea to the passenger quays. The gateways of the oceans deserved to be monumental and impressive; too often they were merely squalid. Provided a port could efficiently discharge its functions there was no limit to its size. If the problem of distribution of industrial works was controlled, cognate industries would have to be adjoining.

The United Kingdom Pilots' Association

A report by Sir John Inskip on certain steps which he has taken in the interests of the United Kingdom Pilots' Association, of which he is general secretary and solicitor, has been published in the March issue of *The Pilot*. He says:—

"I have found it necessary to raise a point with the Ministry of Pensions in connection with the Pensions (Navy, Army, Air Force and Mercantile Marine) Act, 1939. It would appear from Sect. 4 of the Act that a pilot is brought under the scheme only if, at the time when the injury was sustained, the vessel which he was piloting was in the act of entering or leaving a port. I have called the attention of the Ministry to this point, and pressed upon them that if this interpretation of the Act is correct it requires immediate alteration. It may well be that a pilot may sustain an injury from enemy action while engaged in the performance of his duties on a vessel which is neither entering nor leaving a port, and there is no reason, so far as I can see, why there should be this limitation of the right of a pilot to benefit under this scheme. What I have asked for is that any doubt should be removed by putting a pilot in exactly the same position as a master, who by Sect. 3 of the Act is entitled to benefit under any scheme if injury is sustained while he is 'in the service of a British ship.'"

Dealing with local matters at Liverpool, he continues:

"The Mersey Docks and Harbour Board is making application for bye-laws providing for an increase in the main compulsory inward and outward pilotage dues and in certain dock charges to meet the cost of the payment of war risk money to the Liverpool pilots, together with an increase in the main pilot boat rates. The bye-laws have been duly advertised and objections have been lodged by the Chamber of Shipping and the Liverpool Steam Ship Owners' Association. It is understood that the pilotage authority is making this claim solely on the grounds of the serious risks incurred by the Liverpool pilots under war conditions and in order to place them in the same position as members of the Merchant Navy with regard to war risk money. The question of earnings has not been considered in connection with this proposal. The progress of this application will be carefully watched by this Association and at the first opportunity the various ports will be informed as to it."

As regards pilotage in convoy, he makes the following remarks:

"There have been some discussions with regard to the pilotage of ships in convoy, and an Order in Council has just been made adding a new regulation to the Defence General Regulations, 1939, whereby the naval authority may, after consulting the pilotage authority concerned, direct that while the convoy is navigating in compulsory waters, it shall be led by a vessel under the pilotage of a licensed pilot of the district. In such case no other vessel in the convoy shall be allowed to take a pilot, but they shall be deemed for the purposes of the Pilotage Act to be under the pilotage of the pilot on the leading vessel. This means that pilotage will be paid by all the ships in the convoy with the exception of any ships which are exempt from compulsory pilotage. It remains to be seen whether this regulation will operate satisfactorily, and those ports where the necessary direction is made by the naval authority will have to watch carefully the effect of this new order."

Carbon Dioxide Gas in Ships' Hold

A Cargo Handling Risk

The existence of an unsuspected source of danger to stevedores and dock labourers engaged in discharging certain classes of cargo is pointed out in a publication emanating from the United States Bureau of Marine Inspection and Navigation. The danger is due to the possible presence of carbon dioxide gas in the holds of ships, due to their special contents.

The Bureau cites two outstanding instances where fatalities resulted from this source. The first occurred in connection with a shipment of cherries where dry ice had been packed into the hold to keep them fresh and the hatches fastened. The evaporation of the dry ice resulted in the development of carbon dioxide, but being colourless and tasteless, there was no sign of its presence. Five men met their deaths as a result of asphyxiation.

The other case was reported in connection with a little-known cargo, castor pomace, a fruit by-product used as fertiliser. The development of carbon dioxide resulted in one longshoreman (labourer) meeting his death and another was resuscitated with great difficulty. These tragic examples, the Bureau states, bring home the need for the utmost care in the handling of cargo and the proper understanding of the nature and effect of carbon dioxide gas. Workers are warned never to enter a hold or a suspected area without some form of oxygen-breathing apparatus or fresh-air nose mask. Ventilation of cargoes is of primary importance.